For engineers who design and manage the power and plant services

Power

JUNE 1959

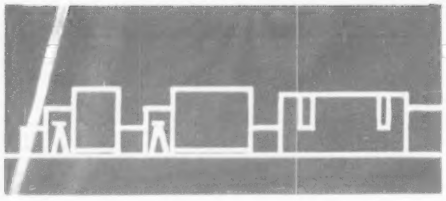
ONE DOLLAR

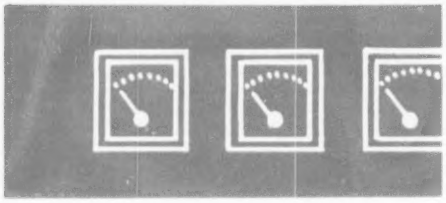
A McGRAW-HILL PUBLICATION

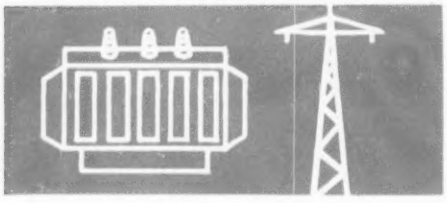
VIBRATION

A 24-page special report on balancing rotating equipment

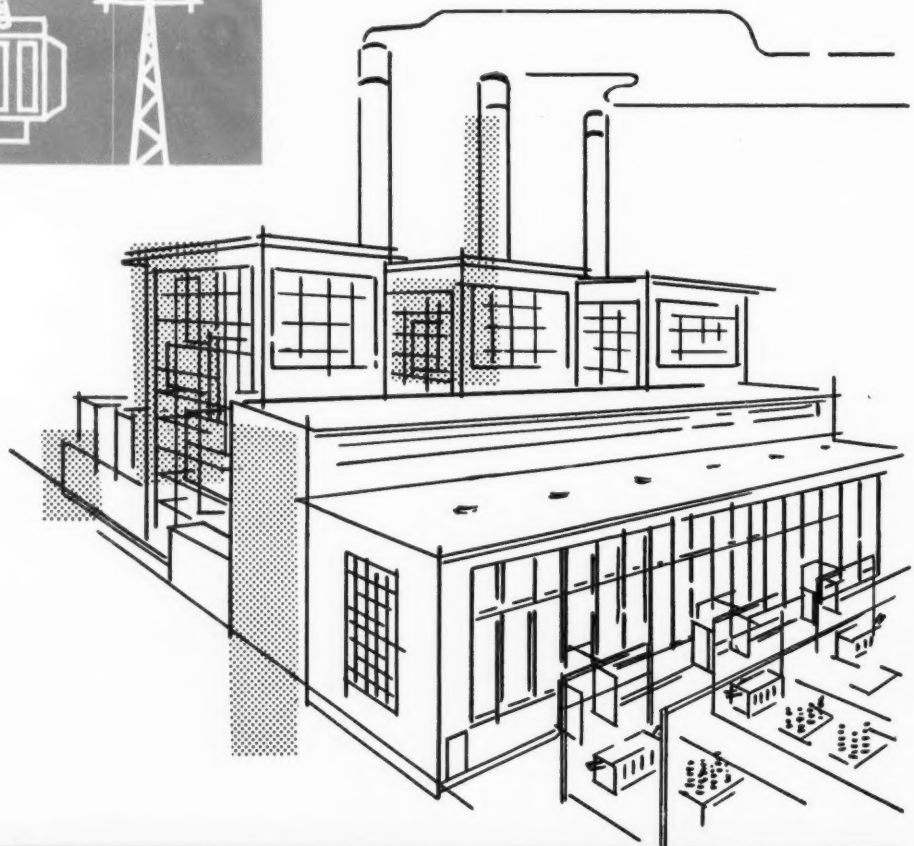
AEG







For 75 years, from the first small plant which supplied houses with electric light to the hundreds of power stations throughout the world that supply cities, industries and railways, AEG experience and coordinated design have served to maintain highest quality and dependability of equipment.



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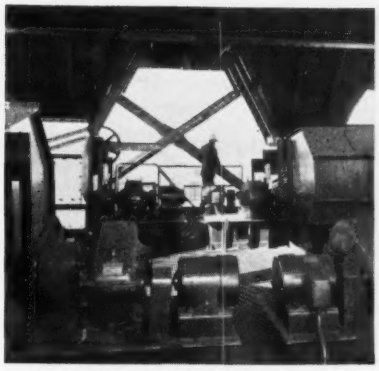
ALLGEMEINE ELEKTRICITÄTS-GESELLSCHAFT

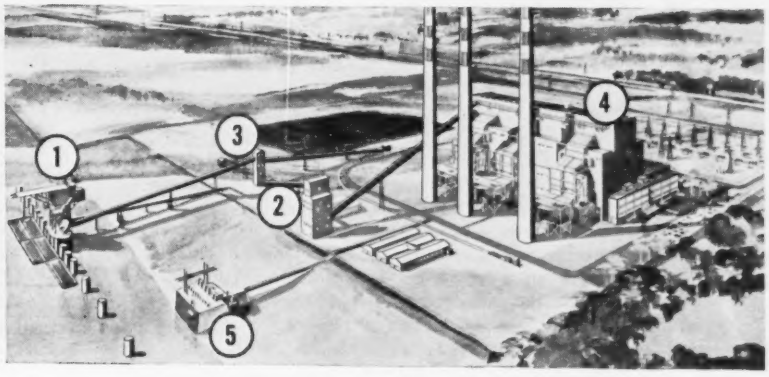
Berlin (West) EXPORT DEPARTMENT Frankfurt (Main)

For more facts circle 201 on Reader Service card, p 125

Directing traffic for 2200 tph



1. BARGE UNLOADING—Coal reclaimed by belt feeders is fed to two belt conveyors delivering to transfer tower where it may be directed to outside storage or bunkers.



LINK-BELT coal handling system adds to efficiency of Thos. H. Allen generating station at Memphis

AT this new and highly efficient Memphis power station, designed by Burns and Roe, Inc., coal is carried from barge to storage to bunkers at capacities up to 2200 tons per hour. The entire system of Link-Belt coal handling conveyors is operated by one man from a central control panel.

This huge Link-Belt coal handling network is a product of more than 80 years' experience. Before the advent of commercial electricity, Link-Belt was already establishing a reputation for efficient coal handling equipment in steam generating plants.

Today Link-Belt serves as a single source and responsibility for complete coal conveying systems or components . . . for both central stations and boiler houses. For details, write to Link-Belt Company, Dept. AV, Prudential Plaza, Chicago 1, Ill. Ask for Book 2410. It shows the latest in layouts and equipment for power plants, large and small.

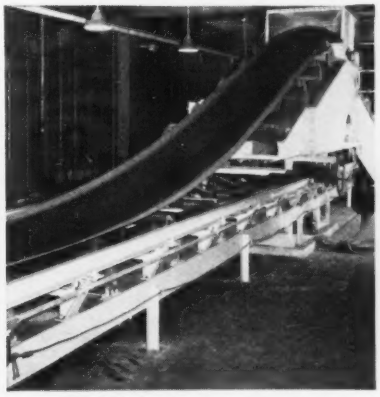
2. COAL CONVEYING—Two Link-Belt 48-in. wide inclined belt conveyors route coal to crusher. Each has a capacity of 1100 tph at speeds of 485 fpm.

LINK-BELT

One source . . . one responsibility for materials handling, processing and power transmission equipment

15,173

3. STOCKPILING is accomplished by the Link-Belt movable and stationary stackers. Both are equipped with Link-Belt 60-in. wide conveyor belts.



4. BUNKER LOADING—Two Link-Belt 48-in. bunker conveyors are equipped with trippers to distribute coal to bunkers at the rate of 1100 tons per hour.

5. SCREENING—Link-Belt bar screen in water intake pump house protects pumps and other equipment from debris, cleans water for condenser cooling.

For more facts circle 204 on Reader Service card, p 125

speaking of **Power**

The unexpected crops up quite frequently in the businesspaper field, as you might expect. In wrapping up this month's issue we had two cases which well illustrate the point.

St. Croix Paper Co in Woodland, Me., working through their consultants, have been doing an outstanding job in the power services. Our lead article, p 71, digs out the many reasons behind their engineering decisions. But about the time we were going to press, word was received that a turbine-oil fire had gutted the plant. The story appears as we had planned, with a last-page reference to the fire. A future issue will carry further details.

Field testing of fire-resistant turbine fluids has been under way, with central stations rather than industrials as the prime target because of relatively higher steam temperatures. Yet the St. Croix fire started in a turbine whose throttle steam temperature was in the 900-F range. For POWER's most recent article on F-R turbine lubricants, see May 1958, p 73.

Balancing rotating machinery, this month's special report, p 213, is a case where a last-minute switch became necessary because we followed an educated guess that backfired. When Associate Editor Steve Elonka started writing the report for this issue he was well aware of the disagreements on terminology among key figures in the balancing industry. Example: Is vibrating equipment in a state of *imbalance* or *unbalance?* In recent weeks the grammatically correct *imbalance* appeared to have taken a foothold. We gambled in this direction even though an ASA decision was coming up.

A few days before press time, ASA Committee S-2-W-36 voted in favor of the more commonly used term *unbalance.* With about 75% of the report in the print shop and all drawings prepared, the temptation was strong to leave things as they were, commenting on the last page of the report. But that course just wouldn't sit right with POWER editors, so we set about changing all the *im*'s to *un*'s.

Lon Rowley

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In Power this month

JUNE 1959 • VOL. 103 • NO. 6 • 77TH YEAR

Editorial: New era in control — 67

DESIGN AND EQUIPMENT APPLICATION

Long-range plans cut paper-mill's costs, can do the same for your plant — 71
How one plant uses a heat pump to keep power services all-electric — 75
Consider operating conditions when you pick your thermal relays — 78
Tips on lowering heat loss from cylindrical surfaces — 81
Centralized instrumentation simplifies water-treatment control — 85
Army Package Power Reactor stops for its first checkup — 88
Mechanical-drive turbine lube-oil systems tackle several duties — 91

DEPARTMENTS

Nuclear notes: News briefs on the latest developments — 96
Comment: Two pages reserved for readers' remarks — 98
Data sheet: Weight of tubes and solid rods — 102
Technical briefs: Digest of latest engineering papers for busy power men — 110
New literature: Yours simply for mailing postage-free Reader Service card — 126
Equipment design of the month: Steam generator is an unfired pressure vessel — 138
Plant equipment news: Your information center for new products and materials — 140
Thermo refresher: How nozzles handle hot-gas flow — 168
Marmaduke Surfaceblow foils a plant magician in the Caribbean — 174
Powerscope: A selective look at this month's power-field happenings — 186
Reports from the field — 188
Calendar of events — 190
Appointments — 198
Engineers' bookshelf — 204
George *Edwards* tells how familiarity breeds contempt . . . or confidence — 210

PLANT MAINTENANCE AND MANAGEMENT

BALANCING ROTATING MACHINERY: A 24-page special report — 213
Unbalance—what causes it, how it's measured — 214
Vibration—the symptom of unbalance — 218
Balancing—machines detect the amount and location of unbalance — 224
Troubleshooting—here are the ABC's of field testing — 234
Stopping boiler explosions is squarely up to you — 237
Plant electrical fact file: Automatic reduced-voltage starting circuits — 238
Plant problems: Here's how Power readers would tackle them — 240
Practical ideas to keep your plant running at peak efficiency — 244
Use modern techniques and materials to clean motor windings in place — 247

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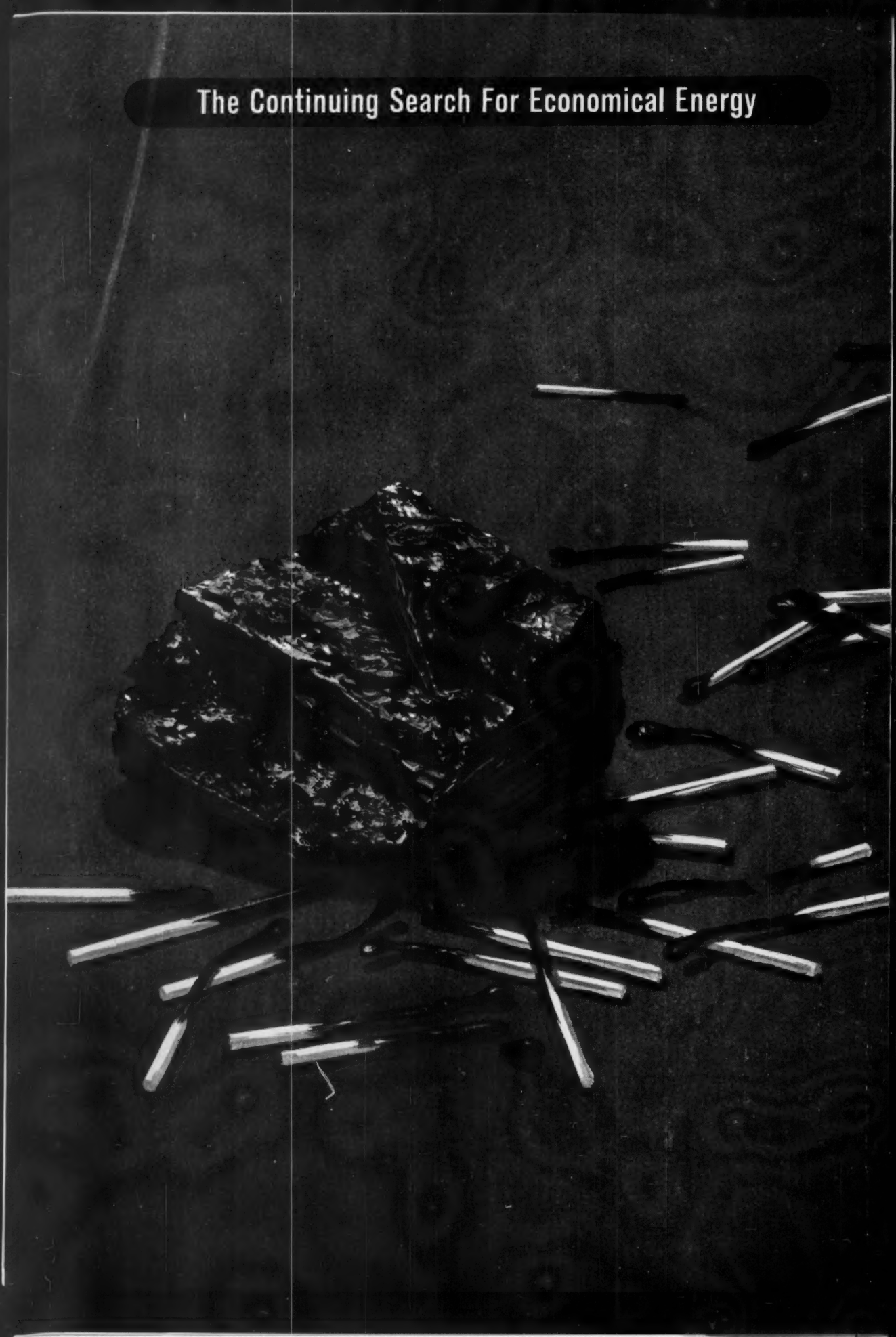

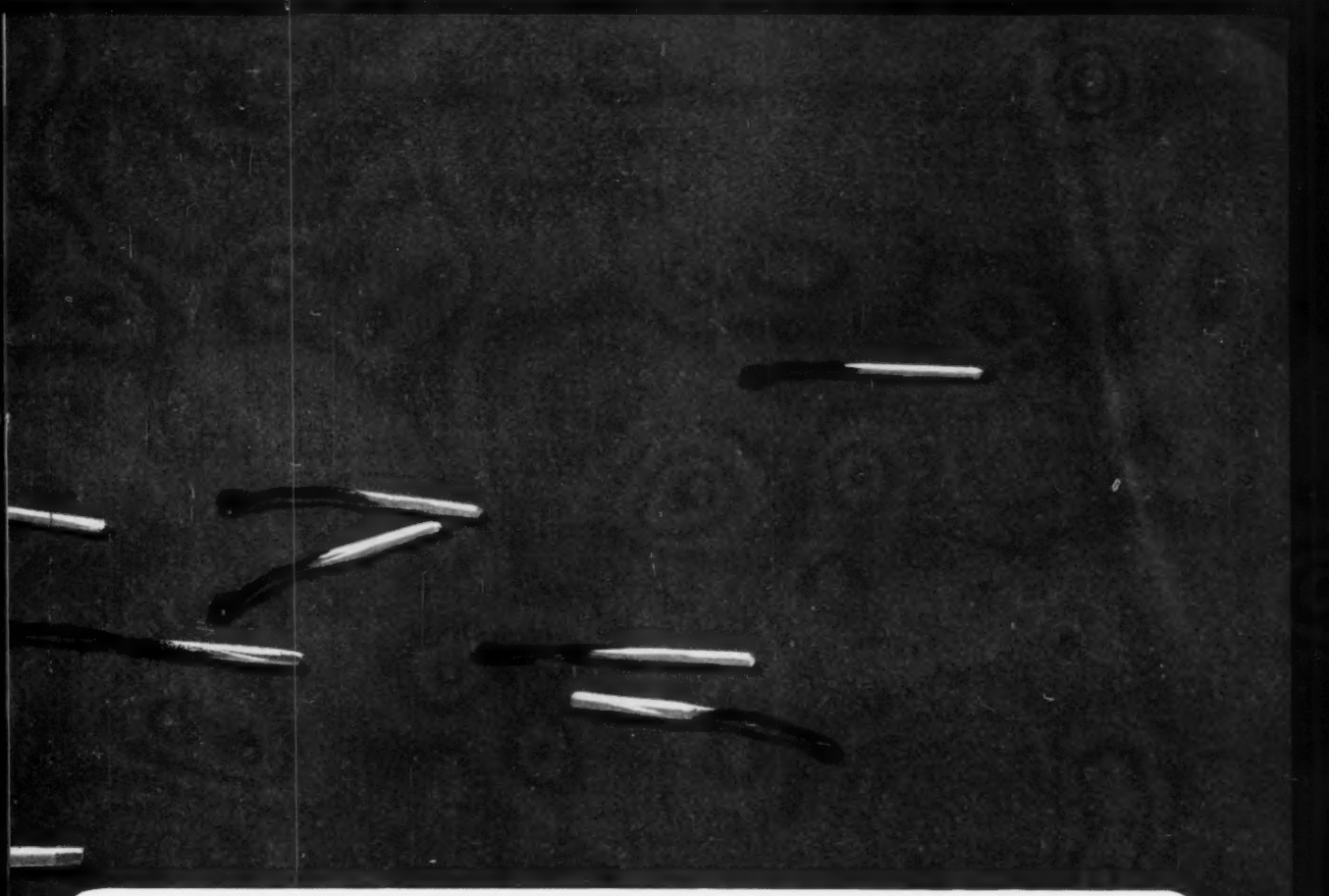

Now—Btu's from coal that "Can't Be Burned"

Utilities who thought it couldn't be done, are now burning low-cost, low-grade, high-ash coal—helping to keep kilowatts America's biggest bargain.

The reason? B&W fuel research that led to the design of the Cyclone Furnace. Fact is, the B&W Cyclone Furnace was *designed* to burn the really "tough" coals—and squeeze the maximum Btu's from every pound.

Behind the Cyclone's success are more than 33,000 B&W fuel analyses. With this tremendous background and experience, B&W can build fuel burning equipment around the fuel *you'll* burn. It means you can utilize available low-cost fuels you could never use before.

Important to you, too, is B&W's complete objectivity in making recommendations. For B&W manufactures all types of fuel burning equipment—for every application. Why not discuss your special requirements with us now. Write to The Babcock & Wilcox Company, Boiler Division, Barberton, Ohio.

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AT ASHLAND, KY. WORKS OF ARMCO STEEL CORPORATION

"Increased boiler capacity can often be obtained by modernizing boiler cleaning equipment. Another benefit of such modernization is more efficient utilization of the fuel . . . getting more heat into the steam for useful work and wasting less heat up the stack.

For example, at the Ashland, Kentucky Works of the ARMCO Steel Corporation there are four boilers that were unable to supply the growing steam requirements of the plant. The high exit gas temperatures suggested that a study be made to determine whether the cleaning could be improved to provide additional capacity. This study indicated that more steam from the same fuel could be expected if high pressure long retractable blowers were used for cleaning instead of the rotary blowers with which the boilers were originally equipped.

The expected results seemed sufficiently promising and it was decided to modernize the cleaning equipment of one boiler. The seven rotary blowers were replaced with four Diamond Long Retracting Blowers, one of which is shown below. This modernization proved to be justified as the boiler's maximum steam output was increased 11% and the exit gas temperature was reduced approximately 100° F.

A "Boiler Cleaning Modernization Program" is well worth careful consideration because it can mean substantial savings in so many ways. In addition to increased capacity and more efficient fuel utilization, there is reduced maintenance . . . also reduced operating costs when motorized units and automatic operation are installed. Even though your boiler cleaning was the best at the time it was installed, improvements since then will probably pay off. For many years Diamond has been doing continuous research to improve boiler cleaning and boiler cleaning equipment.

Ask the nearest Diamond office (or write directly to Lancaster) to make a study of your boiler cleaning . . . the possible savings may surprise you."

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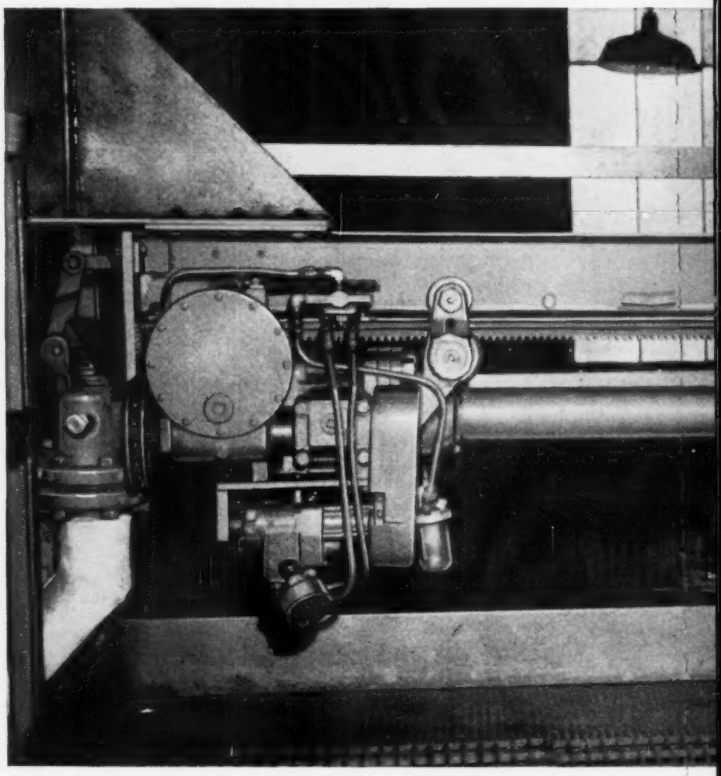

The Mark of

BETTER BOILER CLEANING AT LOWER COST

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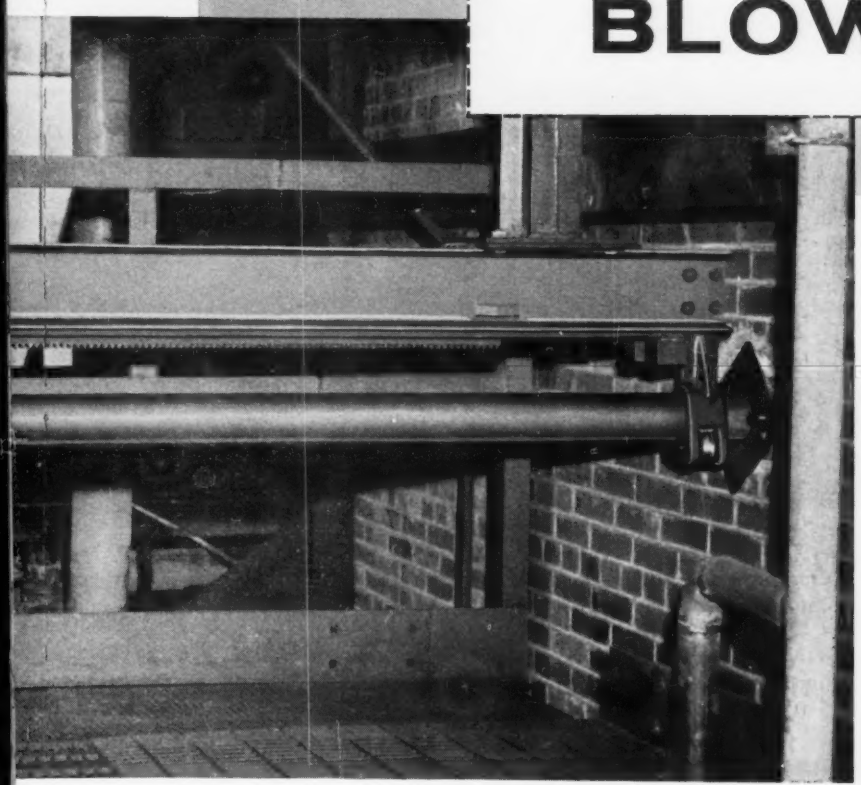
11% More Steam 100° F Lower Exit Gas Temperature

RESULT FROM BOILER CLEANING MODERNIZATION PROGRAM

Using DIAMOND LONG RETRACTING BLOWERS



One of the four Diamond Long Retracting Blowers used to modernize the cleaning of the first boiler at the Ashland Works of ARMCO Steel Corporation. The results were so satisfactory that the three other boilers in this plant are now also being modernized.

8257

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You get these benefits YARWAY GUN-PAKT

Why do industrial plants, institutions, universities and central heating plants SPECIFY and INSTALL Yarway Gun-Pakt Expansion Joints?

Because with Yarway you get:

- **CONTINUOUS SERVICE**

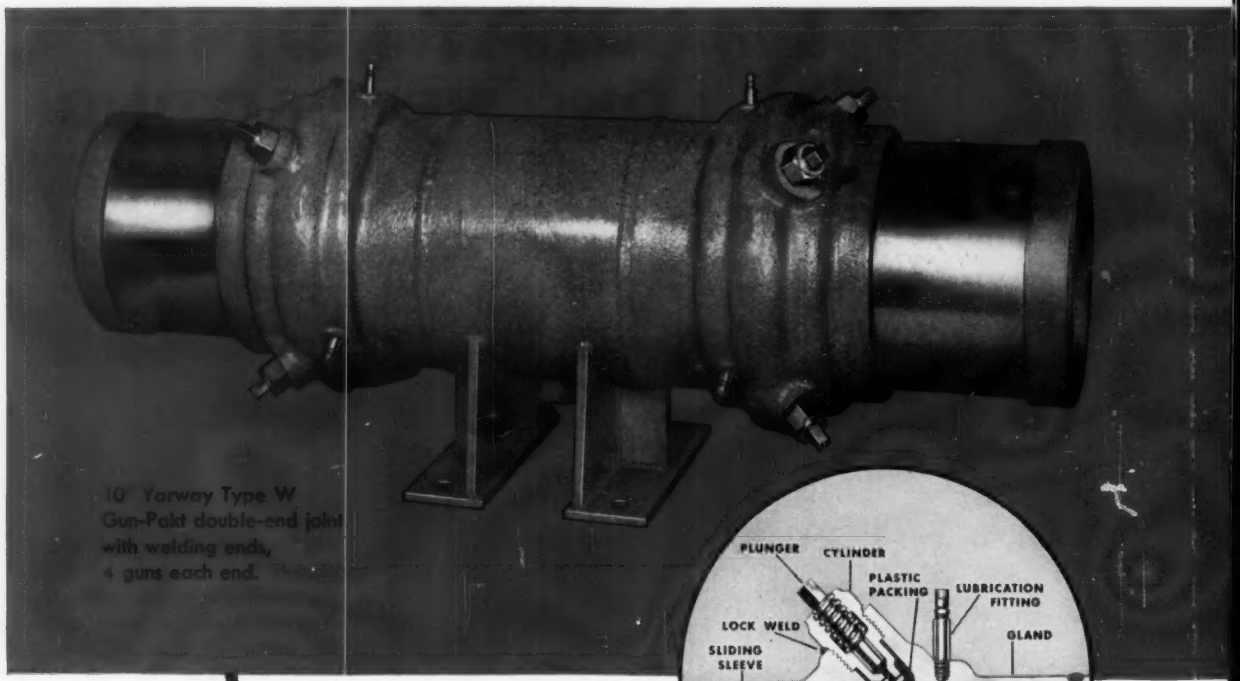
  Costly shutdowns are eliminated. Packing is seldom necessary but may be added *under full line pressure*. No vents are necessary. Never needs repacking.

- **RUGGED DEPENDABILITY ALL STEEL CONSTRUCTION**

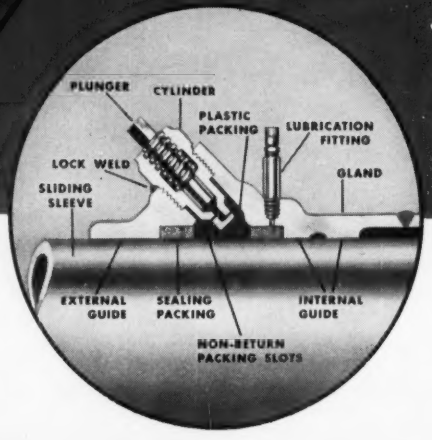
  Durable chromium plated seamless steel sleeves. No chance *of metal fatigue*. Wrought steel bases provide rugged, positive anchorage.

- **INTERNAL AND EXTERNAL GUIDES**

  Positive alignment of sleeve in stuffing box—*where it counts!*



10" Yarway Type W Gun-Pakt double-end joint with welding ends, 4 guns each end.



Cross-section of Gun-Pakt feature. To add packing, just insert a plug and turn the plunger. Note non-return packing slots.

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Requires less space to install—less space to maintain—smaller manholes.

Many Gun-Pakt joints have been *in service over 25 years with only nominal maintenance* —no major repairs or periodic overhauls. Maintenance costs are negligible—records show average to be one manhour and 65 cents worth of packing per joint per year. AND—NEVER A SHUTDOWN FOR REPACKING!

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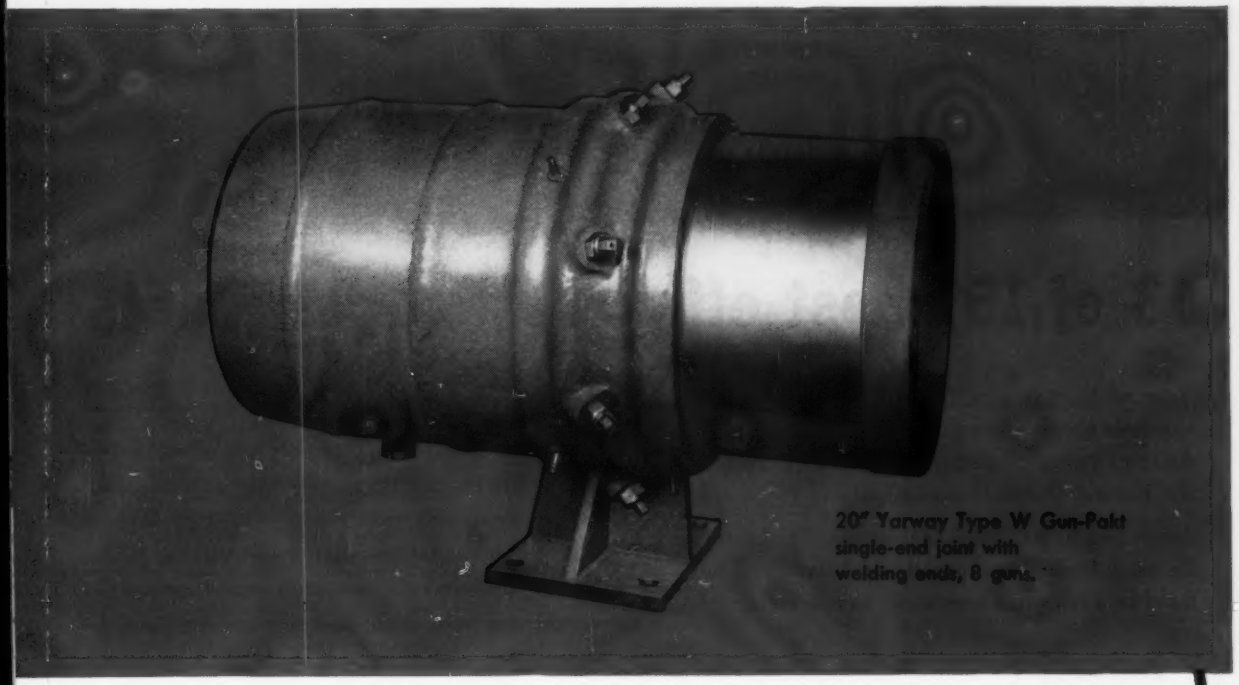
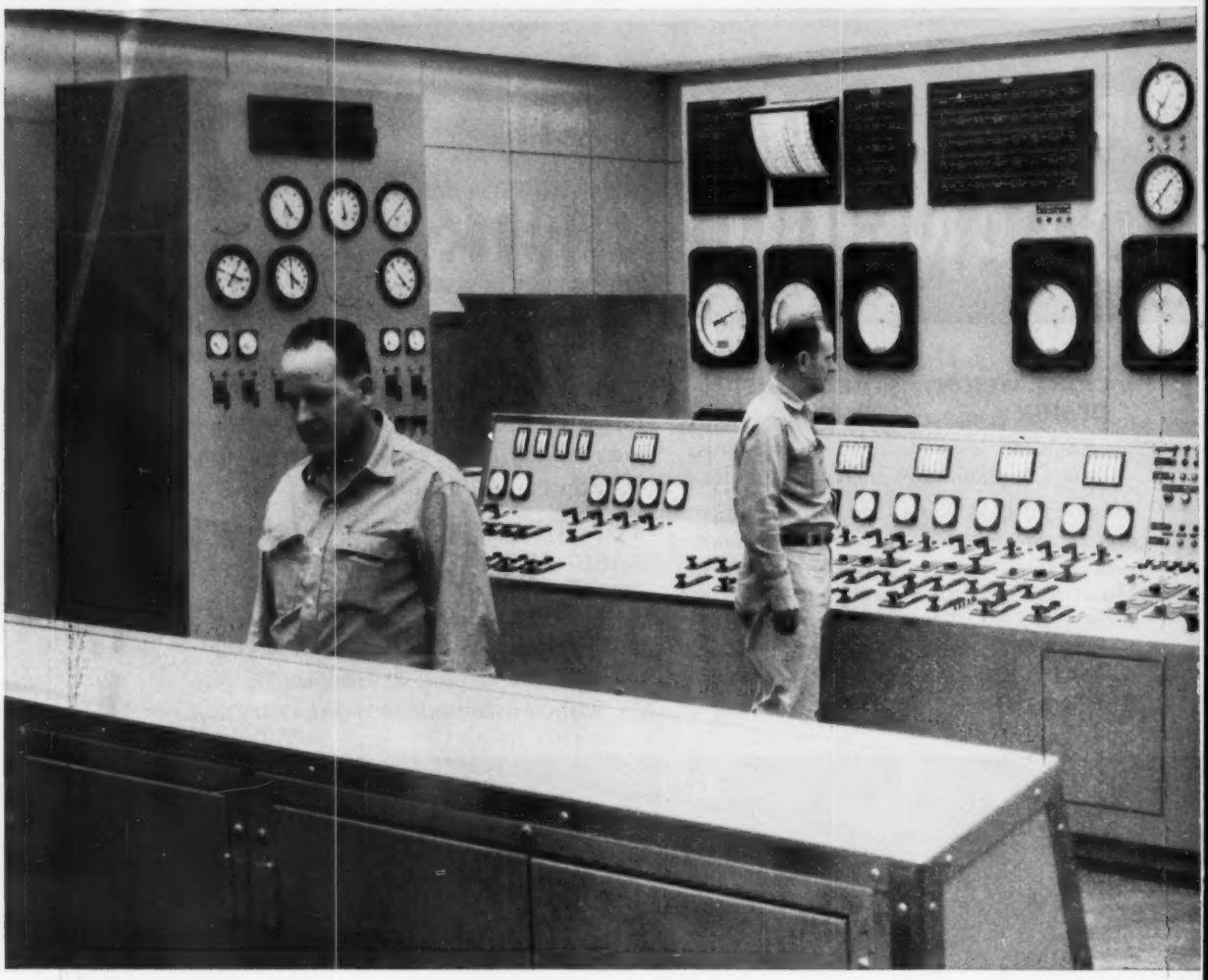


20" Yarway Type W Gun-Pakt single-end joint with welding ends, 8 guns.

YARWAY® GUN-PAKT



13 of 15 "most efficient"* power plants

Year after year you'll find Bailey Meters and Controls keeping sensitive fingers on the pulse of America's *most efficient* power plants (as rated by the Federal Power Commission).

According to the latest box scores, 10 of the top 15 used Bailey equipment exclusively. There must be a reason. There is. In fact, several:

1. Experience

Bailey Engineers have been making steam plants operate efficiently for more than forty years. Veteran engineers and new engineers (the men who represent Bailey) are storehouses of knowledge on measurement and control. They bring you the latest, up-to-the-minute developments that can be applied to your problem.

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Bailey manufactures a complete line of standard, compatible pneumatic and electric metering and control equipment that has proved itself. Thousands of successful installations, involving problems in measurement, combustion and automatic control, are your assurance of the best possible system. You can be sure a Bailey Engineer will offer you the right combination of equipment.

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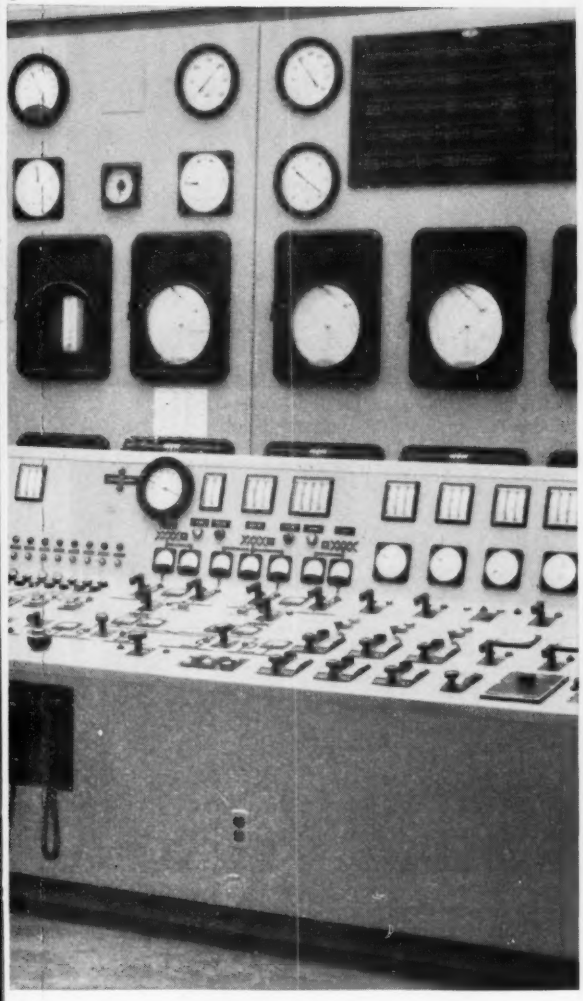
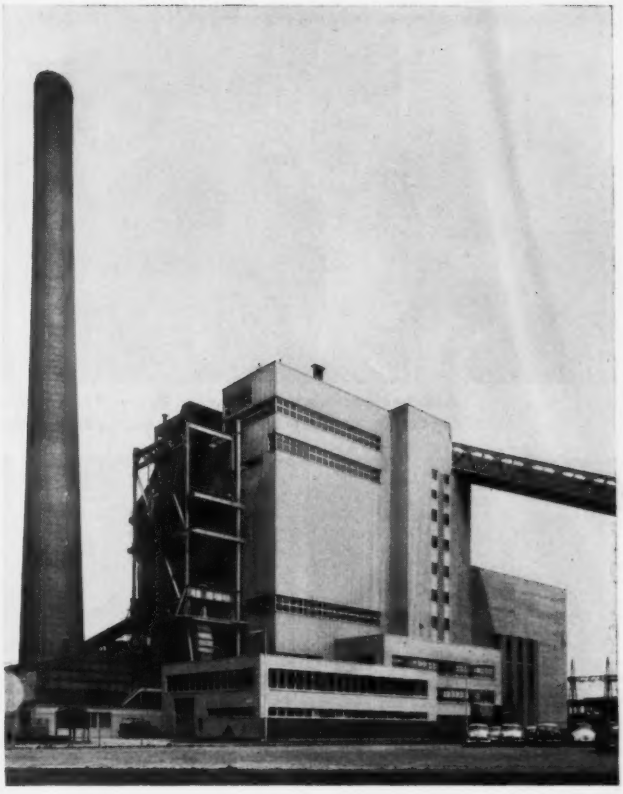
There's a Bailey District Office or Resident Engineer close to you (listed under Bailey Meter Co. in your phone book). Phone for expert engineering counsel.





Bailey Controls for combustion, feed water and steam temperature at the Bay Shore Station of The Toledo Edison Company. The FPC reported a 1957 heat rate at Bay Shore of 9,210 Btu per kwhr, making it one of the 15 most efficient plants in the United States.

depend on Bailey Meters and Controls

✻ 15 MOST EFFICIENT PLANTS 1957 Heat Rates Reported by the Federal Power Commission

	Btu/kwhr	Meters	Comb. Control	Feed Water Control	Supht. Control
1. Kanawha River (Appalachian Electric Power Co.)	9,118	B	B	B	B
2. Muskingum River (The Ohio Power Co.)	9,139	B	B	B	B
3. River Rouge (The Detroit Edison Co.)	9,140	—	—	—	—
4. Clifty Creek (Indiana-Kentucky Electric Co.)	9,147	B	B	B	B
5. Tanners Creek (Indiana and Michigan Electric Co.)	9,180	B	B	B	B
6. Kyger Creek (The Ohio Valley Electric Corp.)	9,201	B	—	B	B
7. St. Clair (The Detroit Edison Co.)	9,210	B	B	B	B
8. Bay Shore (The Toledo Edison Co.)	9,210	B	B	B	B
9. G. G. Allen (Duke Power Co.)	9,349	B	B	B	B
10. John Sevier (Tennessee Valley Authority)	9,350	—	—	—	—
11. Phillip Sporn (Central Operating Co.)	9,370	B	B	B	B
12. Milliken (New York State Electric and Gas Co.)	9,371	B	—	B	—
13. Shawville (Pennsylvania Electric Co.)	9,396	B	—	—	B
14. El Segundo (Southern California Edison Co.)	9,467	B	B	B	B
15. Colbert (Tennessee Valley Authority)	9,490	B	B	B	B

AJ41-2

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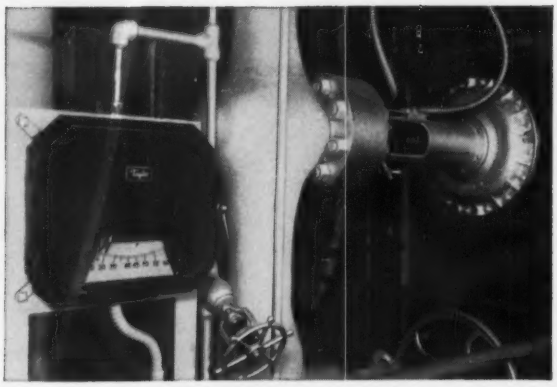
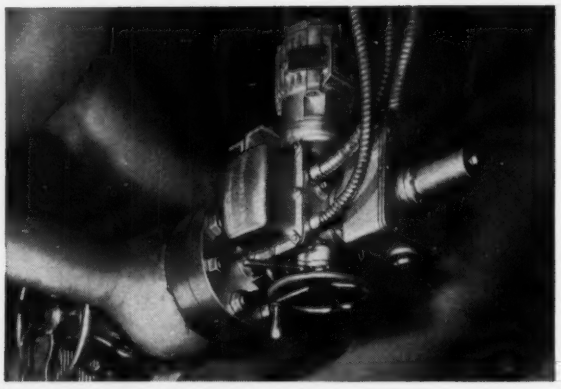
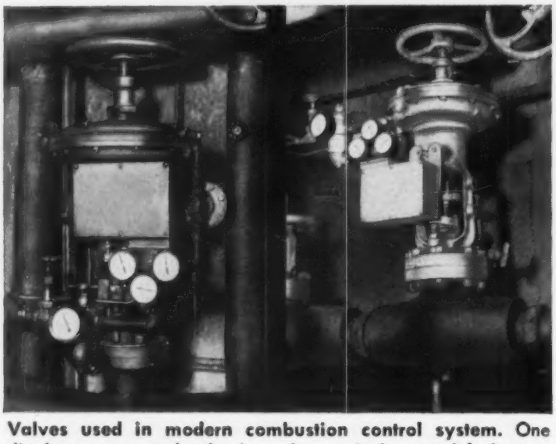
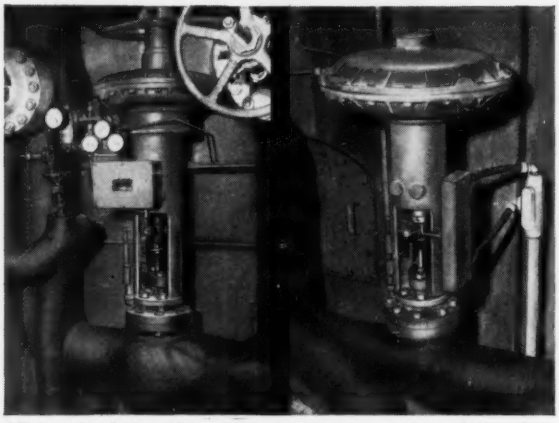




At a key eastern power station Copes-Vulcan valves protect three boiler feed pumps in a recirculation control system (left), and a motor operated valve is used in the feedwater by-pass line (right).



Valves used in modern combustion control system. One diaphragm-operated valve is used as a single-seated fuel return control valve (left) while another controls the speed of the turbine driving the forced-draft fan (right).



Efficient feedwater-flow control system uses a Type CV-D valve equipped with positioner, air lock, and emergency handwheel operator (left). Another diaphragm-operated valve trips automatically if fuel-oil line pressure drops below a safe limit (right).

Copes-Vulcan Regulator Valves bring precision control to exacting jobs

Designed for superior accuracy and long range dependability, Copes-Vulcan valves establish new standards of efficiency for pressure, temperature, flow, and level control.

To assure trouble-free performance, Copes-Vulcan custom designs each valve to suit your most rigid control requirements. The kind of fluid—its flow, pressure, and temperature—are all studied before a recommendation is made. Port area and style are selected on the basis of careful research.

The Copes-Vulcan line includes the following valves:

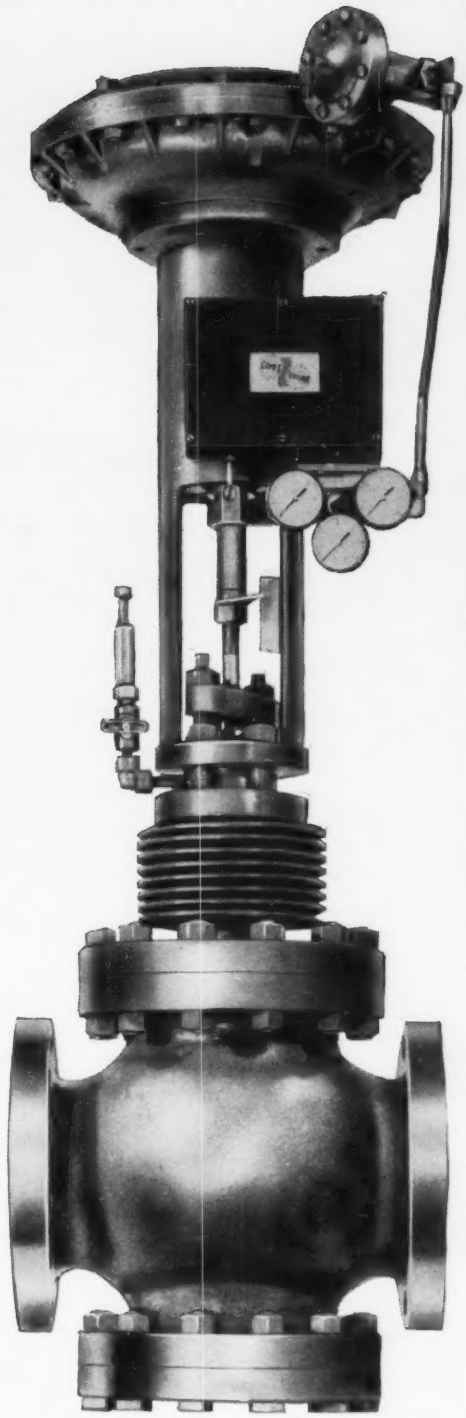
Diaphragm valves (Type CV-D) provide greater versatility . . . have excellent rangeability . . . may be direct or acting.

Piston-type valves (Type CV-P) offer simplicity of design . . . ideal where valve-operating force must be unusually high, where positioning must be precise.

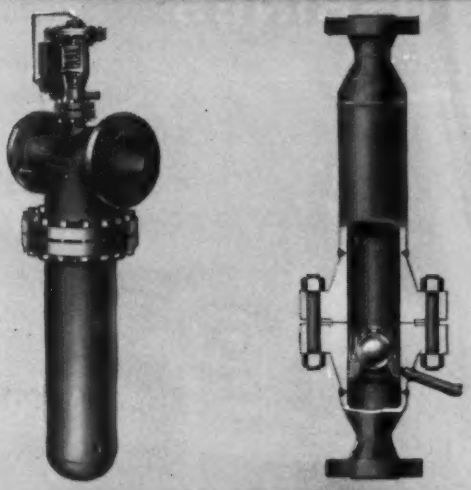
Nuclear valves for ships, atomic plants, and test reactors. Supplying valves for these advanced projects offers proof of the acceptance of Copes-Vulcan's skill and integrity.

Copes-Vulcan Division
BLAW-KNOX COMPANY
Erie 4, Pennsylvania

C-V NEWS NOTES



Type CV-D (diaphragm-operated) valve serves a broad variety of applications in sizes up to 12 inch. Optional features include: cooling fins and stuffing-box lubricator to maintain low friction over long packing life, auto-lock, top or side-mounted handwheel for emergency operation.

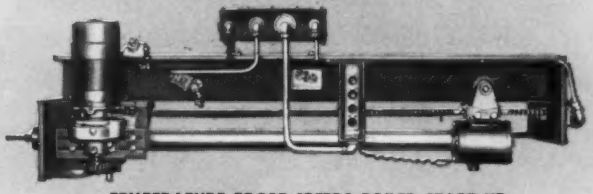


DESUPERHEATERS TO MEET EVERY NEED

Carburetor desuperheaters permit final steam temperature to be as low as 10°F. above saturated-steam temperature at the stated pressure. Using a standard controller, final temperature may be held within 5°F. Write for Bulletin 1056.

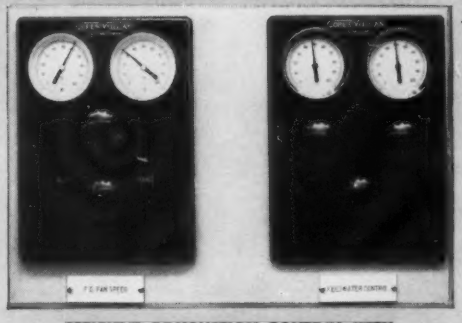
Variable-Orifice desuperheater is used where permanent pressure loss must be held to less than 5 psig on maximum load. It controls accurately over a 50 to 1 load range, needs no long runs of piping or spray nozzles. Write for Bulletin 1037.

Also available: For intermediate control range of 15 to 100 per cent of maximum, an in-line *Steam-Assist* Desuperheater. Write for Bulletin 1024A.



TEMPERATURE PROBE SPEEDS BOILER START-UP

This probe determines furnace temperature from lighting off until unit is ready to go up to pressure and load. It registers its position as it indicates instantaneous temperatures to give the operator a constant check on potential hot spots that might develop. Standard thermocouple, mounted on the end of the lance, is suitable for temperatures to 1850°F. The probe moves back and forth across the furnace at six feet per minute. It is available for travel up to 30 feet. Write for Bulletin 1048.



EFFICIENT COMBUSTION CONTROL WITH PNEUMATIC CONTROL STATIONS

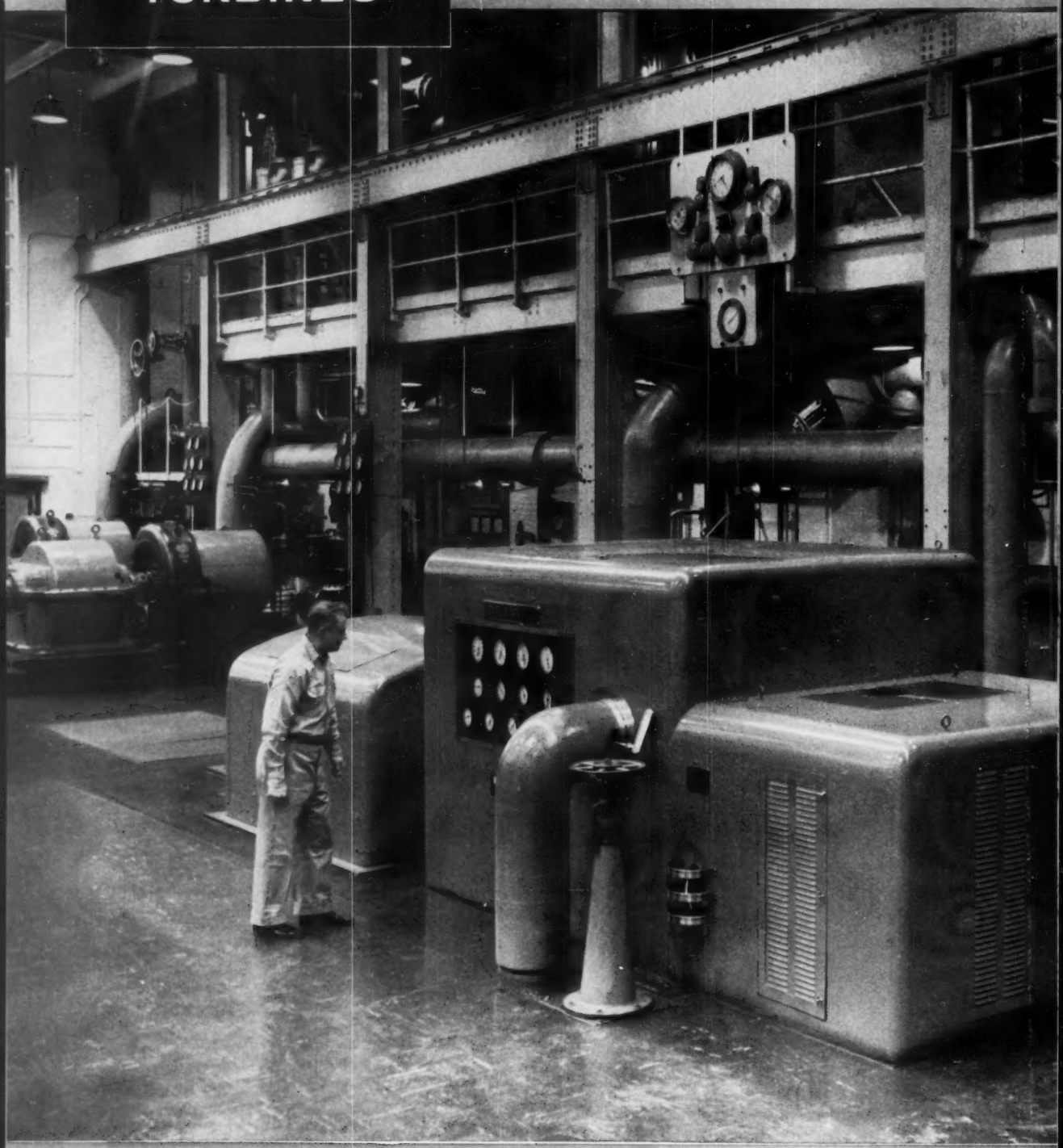
The AM-4 selection station (left) indicates an automatic loading, or originates a manual loading. The AM-4 remote-set auto-manual station (right) gives manually-adjustable set-point loading, or independent manual operation.

These are just two examples of a complete line of pneumatic control stations that offer simple automatic-to-manual selection without the complication of seal balance. They indicate process-variable, controller, and manual loadings. Transfer is "bumpless" without process disturbance. Write for Bulletin 1031.

For more facts circle 209 on Reader Service card, p 125

DE LAVAL STEAM TURBINES

for process industries



The photograph above shows a De Laval direct-connected turbine generator installation at Parke, Davis & Co., Detroit, Michigan.

This controlled extraction, controlled back-pressure unit supplies 2000 kw using process steam. Extraction is at 130 psig, exhaust is 5 psig. This new machine was added to already existing De Laval units that have been in service for 30 years. In addition, the Parke-Davis Research Laboratories in Ann Arbor, Michigan will soon be using a new 1000 kw unit.

DL-649

Parke, Davis & Co. uses DE LAVAL Steam Turbines for process and power generation

Proved economy, dependable service

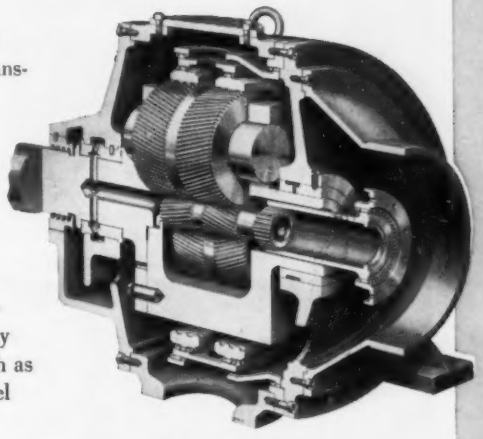
In many process industries, an important by-product is economical electric power. If appreciable quantities of process steam are used, power generation can be achieved at comparatively low cost.

De Laval, pioneer in high speed rotating machinery, has continued to maintain engineering and manufacturing leadership. If you have process application where low-cost power generation can be utilized, call on De Laval.

De Laval-Stoeckicht Planetary Gears

In many applications where high speed and high horsepower are transmitted, the De Laval-Stoeckicht planetary gear can be used to great advantage. It is also used as a speed increaser or decreaser in many industrial installations.

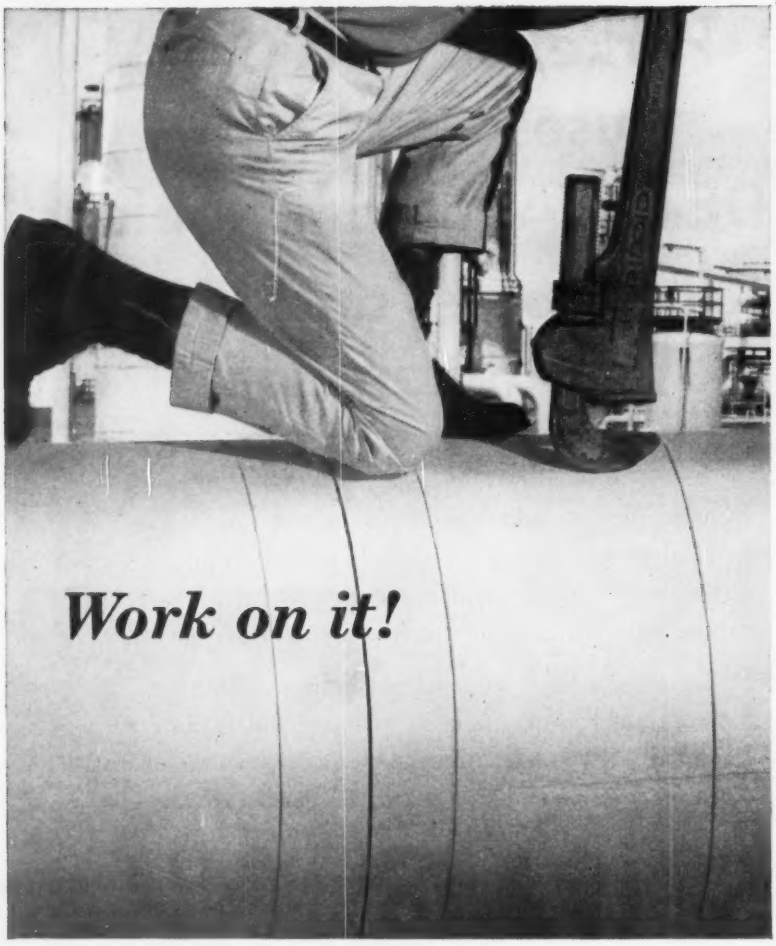
Among its outstanding characteristics are light weight, in-line construction and space saving. It may be used for all kinds of drives such as gas turbines, steam turbines, diesel engines, etc.

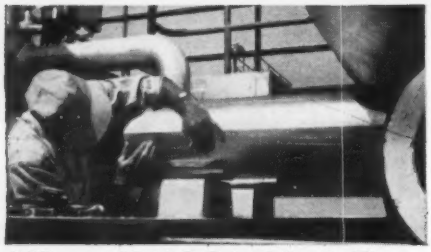


Write for Bulletin 2400

DE LAVAL *Steam Turbine Company*

815 NOTTINGHAM WAY, TRENTON 2, N. J.





J-M's new Metal-On® insulation is Thermobestos prejacketed in aluminum. Snaps on pipe quickly . . . surely. Saves the time and cost of separate on-the-job metal application.

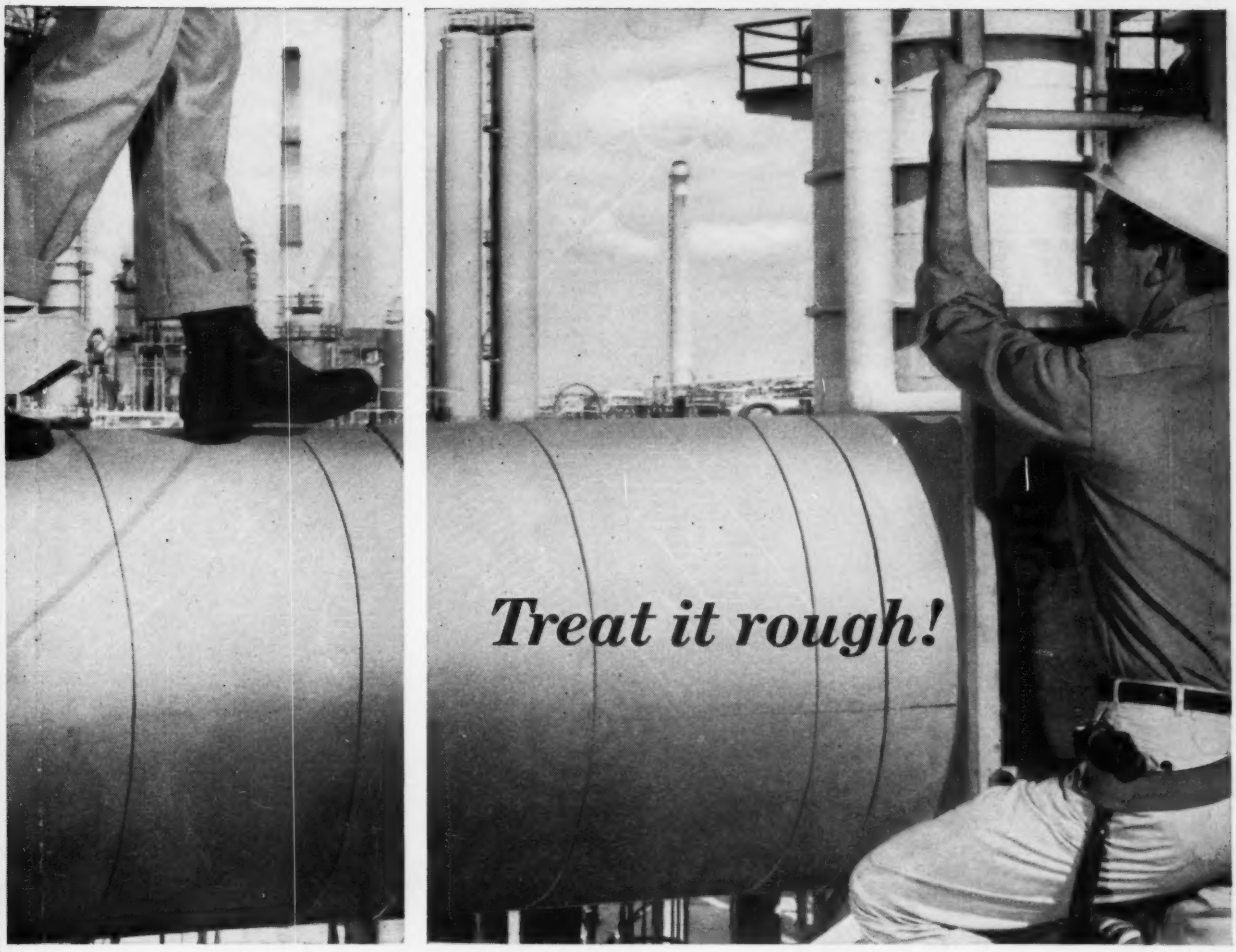
Seminars on best installation practices. For plant foremen who wish to keep up to date on new insulation methods and installation practices, J-M regional sales offices will gladly conduct insulation seminars. Contact nearest J-M office.

It's tough, durable Johns-Manville

Here's why Thermobestos is the preferred high-temperature calcium-silicate insulation . . . to 1200 F

You know the kind of treatment pipe insulation must take . . . day after day, year after year!

There's no better reason than this for the spiraling growth in Thermobestos® applications throughout the process and power generation industries —an insulation so strong and rigid, so resistant to crushing and compression it is almost structural.

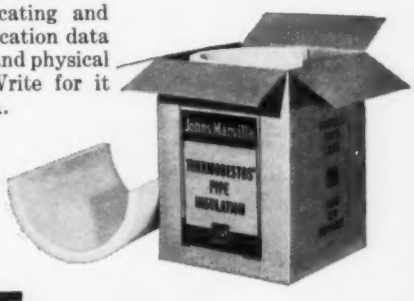


THERMOBESTOS insulation!

Equally important is the ability of Thermobestos to keep fuel costs low. Its *k* factor is the lowest of all insulations generally accepted for process applications. Its moisture resistance, unsurpassed.

Furnished in large, lightweight sections—precision-molded to unusually close tolerances—Thermobestos is easy to handle and install . . . readily adaptable to shop fabrication of fittings and bonds. Large selection of sizes, thicknesses (and quads up to 33″ pipe size) permit calcium-silicate installations that are entirely Thermobestos insulation.

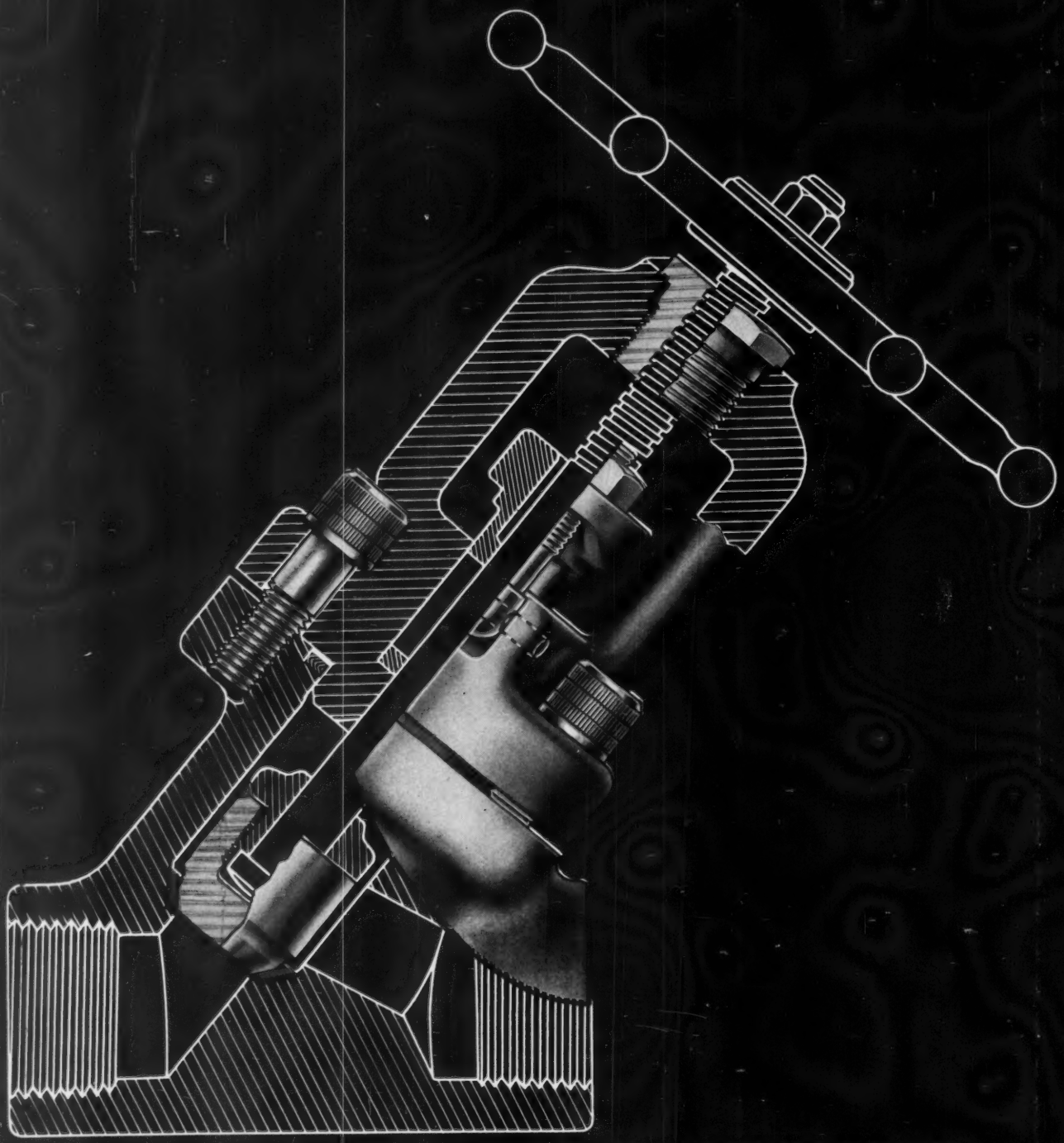
You'll want the new Thermobestos booklet for your technical file. It contains complete information on prefabricating and installation practices . . . specification data . . . heat transmission tables . . . and physical and thermal characteristics. Write for it today. Ask for booklet IN-169A. Address Johns-Manville, Box 14, New York 16, N.Y. In Canada, 565 Lakeshore Rd. East, Port Credit, Ontario.



JOHNS-MANVILLE JM PRODUCTS

JOHNS-MANVILLE

For more facts circle 211 on Reader Service card, p 125



EDWARD "848" SERIES GLOBE VALVE
(ANGLE TYPE ALSO AVAILABLE)

What's New from Edward Valves

New Products . . . Problems and Solutions. . . Information on Steel Valves from Edward, Long-Time Leader in the Field!

Major Improvements at No Extra Cost Mark New "848" Series Forged Steel Stop Valves

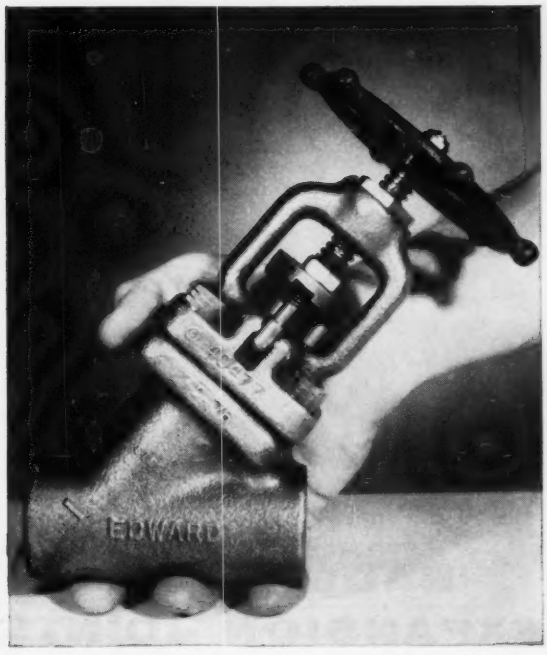
In an industry where any change in design is "news," Edward is proud to introduce a new line of 600-lb forged steel stop valves with so many major design improvements *at no increase in cost.* These Rockwell-built Edward valves are suitable for air, water, oil and other hydrocarbons, anhydrous ammonia and other gases, steam and other non-corrosive fluids.

NEW MATERIALS USED THROUGHOUT

Besides tough drop-forged steel, which is the basis of these valves, Edward introduces such innovations as stainless steel gland bolts, an aluminum-bronze yoke bushing, solid disk of chromium-cobalt-tungsten stainless steel, spiral wound gasket of stainless steel and asbestos, and special alloy cap screws linking body and bonnet.

NEW IMPROVED BODY-BONNET JOINT

Four molybdenum alloy cap screws secure bonnet to valve body. These compact, high-strength cap screws require less space than ordinary nuts and bolts, can be handled with one hand, and deliver maximum compressive force with minimum tightening torque. A new spiral wound gasket, consisting of some 20 turns of stainless steel and asbestos, provides controlled compression not possible with ordinary flat gaskets. Because this spiral wound gasket is free to expand and contract as needed, it "takes up the slack," maintains a leak-proof seal between body and bonnet.



NEW SOLID DISK OF SPECIAL ALLOY

Disk is made of chromium-cobalt-tungsten stainless steel. This new alloy has added resistance to erosion, holds its hardness better under high temperatures than other disk materials. Disk is lock-welded to disk-nut, eliminating wobble and chatter—especially important when valve is called upon for throttling duty.

INTEGRAL STELLITE SEAT FOR LONG LIFE

Valve seat is Stellite—a harder, longer-wearing material with excellent resistance to corrosion, erosion and temperature. Seat is integrally welded to body.

"848" SERIES ROCKWELL-BUILT EDWARD VALVES are available in ¼", ⅜", ½", ¾" and 1" sizes. They are rated at 600 psi—at 910F in carbon steel and at 1030F in chrome-molybdenum steel. Globe or angle types, with screwed or welding ends. Write for facts on performance . . . price . . . and delivery. Address *Edward Valves, Inc., **1230** West 145th Street, East Chicago, Indiana.* (Subsidiary of Rockwell Manufacturing Company.) Represented in Canada by Lytle Engineering Specialties, Ltd., 360 Notre Dame St. W., Montreal 1, Quebec.

EDWARD STEEL VALVES

another fine product by

ROCKWELL

Catalog 14 contains full data on the complete Edward line of forged and cast steel valves from ¼" to 18"; in globe and angle stop, gate, non-return, check, blow-off, stop-check, relief, hydraulic, instrument, gage and special designs; for pressure up to 10,000 lbs; with pressure-seal, bolted, union or welded bonnets, with screwed, welding or flanged ends.

For more facts circle 212 on Reader Service card, p 125

(Advertisement)

Expansion Joint Design Moves out of the "Model T" Era

Badger first began fabricating packless metal bellows expansion joints more than 35 years ago. These "Model T" joints performed (and are still performing) with outstanding success in hundreds of process and steam line piping installations.

Starting in the 30's other expansion joint manufacturers entered the field. The most successful adopted many of the basic features of the original Badger design.

During the last decade, as industry's requirements became more stringent, and joint manufacturers gained fabricating and field experience, certain fundamental problems inherent in the early designs became evident. Most of these problems were solved through a series of modifications. (Among which was the Badger Directed Flexing Self-Equalizing Joint — the famous "DFSE" Design.) But, at best, the modifications were stop-gap measures which complicated the joints and greatly increased their weight. A fundamental reassessment of expansion joint engineering data was needed. Badger led the way: In 1956, a task force completed a three-year research program and the first S-R (Service-Rated) Expansion Joints were produced.

In the three years they have been available, S-R Expansion Joints have been both an engineering and a sales success. But like many revolutionary concepts which upset tradition, the full implication of the advantages S-R Joints offer is still not universally understood. The message that follows is an attempt "to set the record straight."

• • • • •

Equalization — fact and fiction

Many users of expansion joints are under the impression that the so-called "equalizing" rings on today's conventional type expansion joints distribute movement equally among all the corrugations of the bellows. It is argued that as the joint absorbs thermal movement, the tops of the rings progressively come into contact until the bellows is fully compressed thus limiting the amount of compression which any one corrugation can ultimately absorb (see diagram 1). In *this* sense the rings do contribute to the "equalization" of movement by physically limiting the compression of each corrugation to the distance between any two adjacent rings.

Diagram 1

Conventional Type Expansion Joint. Cross-sections of rings and bellows of a conventional "self-equalizing" joint showing cold and hot positions. Note that true equalization of movement can only be obtained when tops of all rings are in contact — an impractical and dangerous situation.

Note, however, that the degree of compression will not be truly equalized until the tops of all the rings are in contact. But, when such a condition occurs, serious problems will result. If the limit of compressibility is reached before the thermal expansion has been completely absorbed, exceedingly large forces will be transmitted through the pipe line to the anchors and connected equipment. On the other hand, if the joint is compressed only partially, not all of the corrugations will absorb movement to the same degree.

How S-R Joints solve equalization problem

Badger S-R Expansion Joints feature the new Curvilinear Corrugations which naturally assume an "all curve" shape under pressure (diagram 2), assuring more equal distribution of stresses throughout the bellows material. Furthermore, the shape, height and pitch of the corrugations are based on a carefully engineered correlation. Thus, reasonably equal distribution of movement among the corrugations is obtained, even in joints not equipped with reinforcing rings.

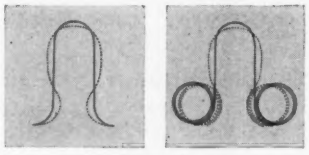


Diagram 2

Badger S-R Expansion Joint. Cross-sections of S-R Joints (Series 50 left, Series 150 right). The movement of the corrugations is shown by dotted and solid lines. Compare configuration and effective height of corrugations, position and size of rings with conventional joint.

Equalization of movement is inherent in the design and functioning of the bellows on Badger S-R Joints. On the basis of provable engineering criteria, the prime purpose of reinforcing rings of any design is to retain the hoop dimension (diameter) of the corrugations when they are subject to internal pressure. This Badger's simple, lightweight tubular reinforcing rings do. But, in addition, the new tubular shape of the rings does contribute to joint flexibility and life by permitting flexing over a more effective portion of the total corrugation height than conventional cast or fabricated equalizing rings.

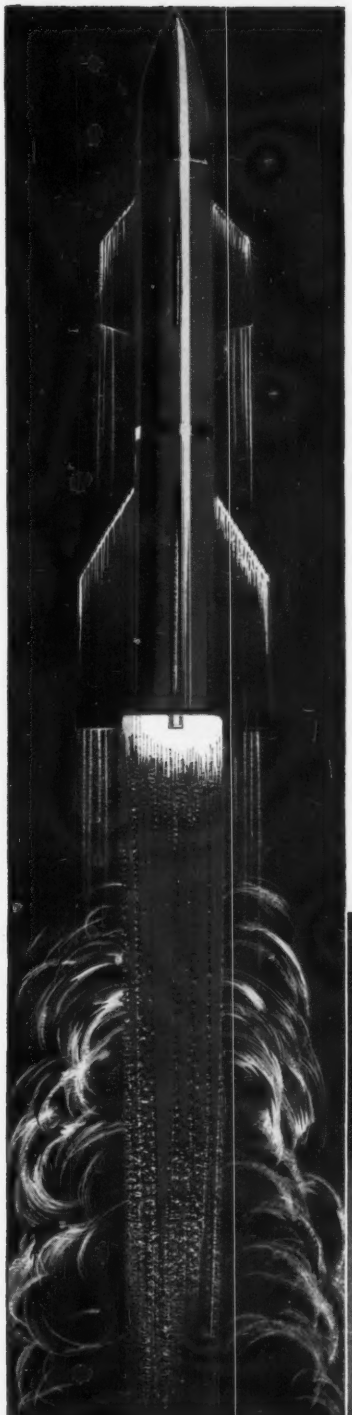
Better performance, lower cost

Briefly, then, Badger S-R Joints alone offer these advantages: Better equalization of movement which results in elimination of localized stresses and leads to longer joint life; a simple, lightweight design that makes installation easier, eliminates cumbersome castings and fragile mechanical devices; complete range of sizes from 3″ to 72″ made from any workable metal and with a wide choice of accessories.

Badger S-R Joints are probably the answer to your problem. There's an easy and quick way to find out — ask the Badgerman for his recommendations. Write or phone today. Badger Manufacturing Co., 230 Bent St., Cambridge, Mass.

© COPYRIGHT 1959 BADGER MFG. CO.

BADGER S·R EXPANSION JOINTS



at Callery's new HiCal® plant

HEAVY-DUTY IR COMPRESSORS

work full-time to produce

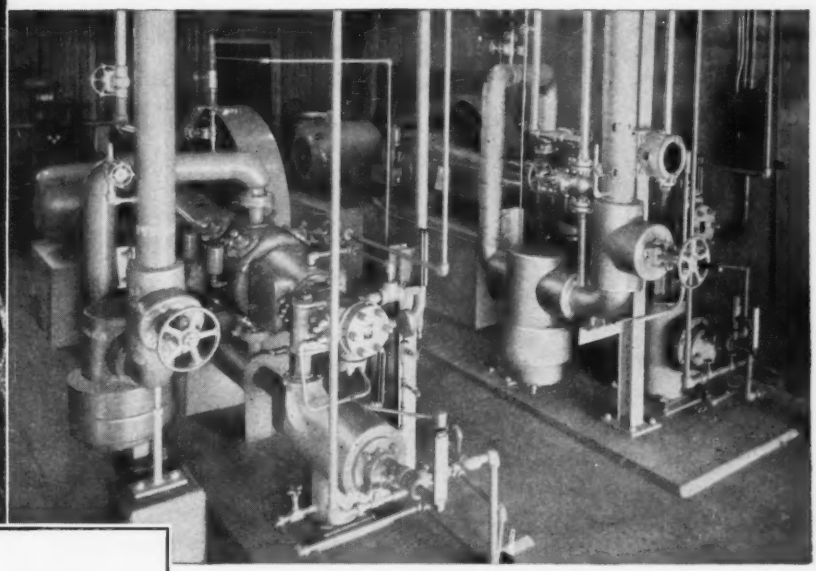
NEW HIGH-ENERGY FUEL

Recently the U.S. Navy and the Callery Chemical Company jointly dedicated their new HiCal plant in Muskogee, Oklahoma—America's first large-scale facility for the production of boron-based high-energy fuel. This new exotic fuel will power missiles, super aircraft, and possibly even man's first steps into space.

A large assortment of Ingersoll-Rand process compressors and pumps at Muskogee are working around the clock to maintain a continuous production schedule. One of the major processing units is the gas plant which produces hydrogen, carbon dioxide and nitrogen. Here a new-design Ingersoll-Rand ESH two-stage compressor handles carbon dioxide at 305 psig discharge, and another two-stage I-R unit compresses nitrogen to 500 psig. Two three-stage TVH's compress the hydrogen to 310 psig.

The Muskogee plant also includes 47 Ingersoll-Rand centrifugal pumps of various types and ratings.

Ingersoll-Rand's leadership in the manufacture of process equipment is the result of the world's most comprehensive compressor experience. Ingersoll-Rand now makes the widest range of compressors of all types, including reciprocating, centrifugal, axial-flow and jet units. Your Ingersoll-Rand representative will be happy to give you more information on gas or air compressors for any process requirement.



Ingersoll-Rand two-stage compressors at the new HiCal plant. At left, an ES nitrogen compressor; at right, compressing carbon dioxide, is an ESH unit of revolutionary new design.

Only IR compressors have **CHANNEL VALVES**

Known for high efficiency, quiet operation and exceptional durability. Entirely different. Each valve is a combination of rigid stainless-steel channels and bowed leaf springs, with trapped-air spaces which cushion action, prevent impact.

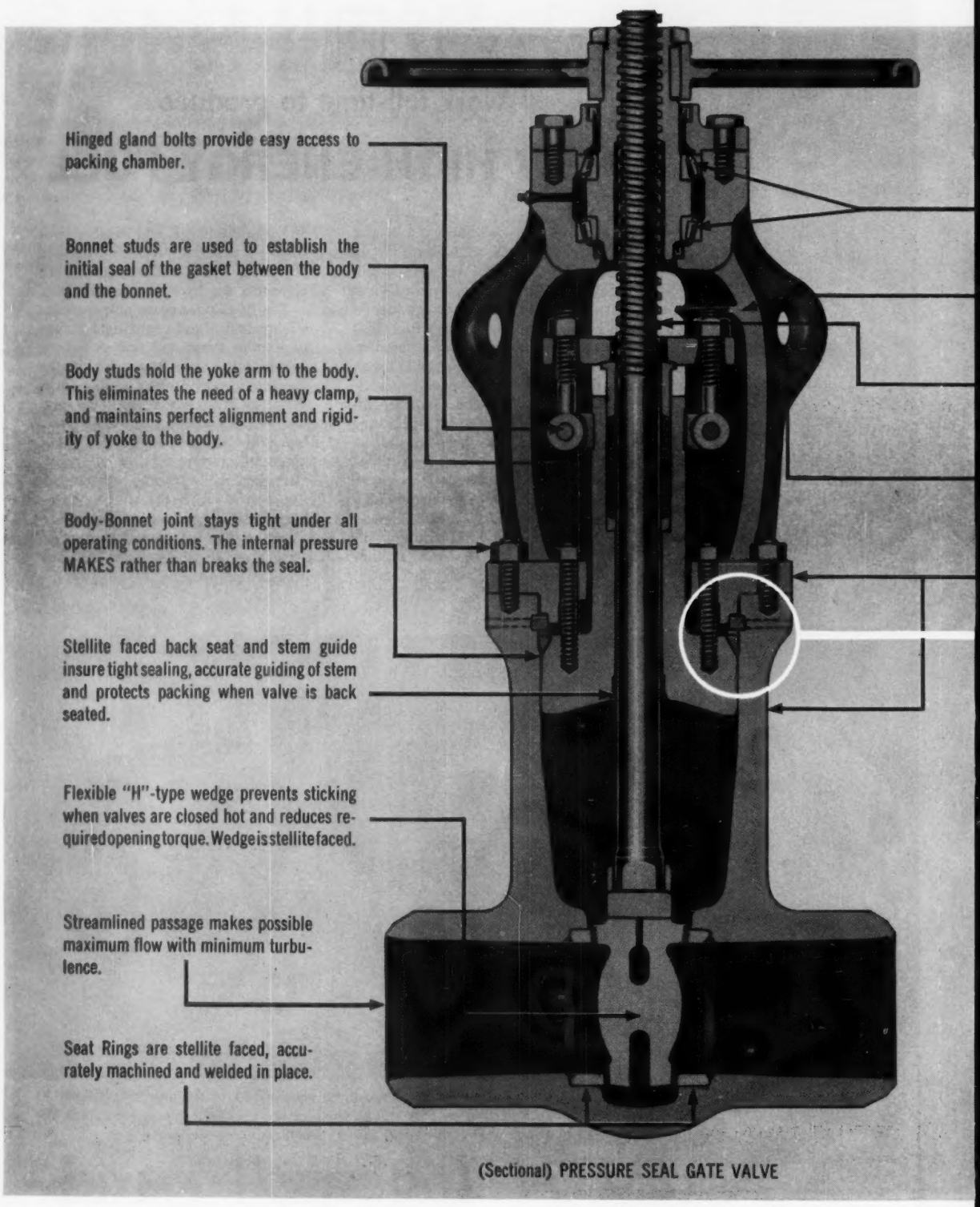
Ingersoll-Rand

I-901 11 Broadway, New York 4, N. Y.

COMPRESSORS • GAS & DIESEL ENGINES • PUMPS • AIR & ELECTRIC TOOLS • CONDENSERS • VACUUM EQUIPMENT • ROCK DRILLS

For more facts circle 213 on Reader Service card, p 125

ADVANTAGES OF **POWELL**


Hinged gland bolts provide easy access to packing chamber.
Bonnet studs are used to establish the initial seal of the gasket between the body and the bonnet.
Body studs hold the yoke arm to the body. This eliminates the need of a heavy clamp, and maintains perfect alignment and rigidity of yoke to the body.
Body-Bonnet joint stays tight under all operating conditions. The internal pressure MAKES rather than breaks the seal.
Stellite faced back seat and stem guide insure tight sealing, accurate guiding of stem and protects packing when valve is back seated.
Flexible "H"-type wedge prevents sticking when valves are closed hot and reduces required opening torque. Wedge is stellite faced.
Streamlined passage makes possible maximum flow with minimum turbulence.
Seat Rings are stellite faced, accurately machined and welded in place.

(Sectional) PRESSURE SEAL GATE VALVE

POWELL...world's largest family of valves

PRESSURE SEAL VALVES!

Pressure Classes...600, 900, 1500, 2500 Pounds and Higher... ALL COMMERCIAL SIZES

Pressure Seal Gate Valve

Tapered roller bearings are most satisfactory for high thrust loads.

Lugs on the inner side of yoke arms provide a convenient shelf for suspending gland when renewing packing.

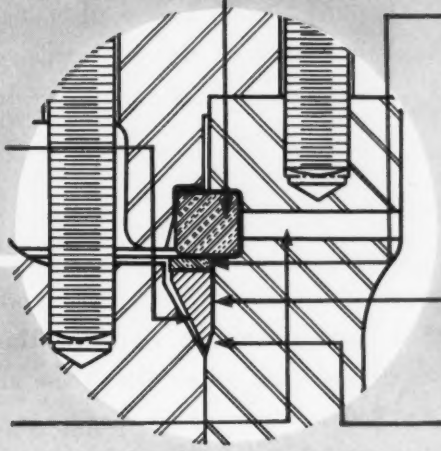
Accurately ground stem threads reduce friction and prolong the life of the stem and bushing.

Lifting lugs facilitate handling the valve during erection and maintenance. Also provide means for supporting weight of the valve.

Streamline contour of body simplifies application and reduces cost of insulation, and effects marked savings in space and weight.

Segmental thrust rings absorb all the thrust applied by internal pressure. This design enables valve to be easily assembled and disassembled.

A hardened stainless steel protective ring prevents deformation of the top surface of the soft metallic gasket.



A differential angle between gasket and bonnet assures line contact.

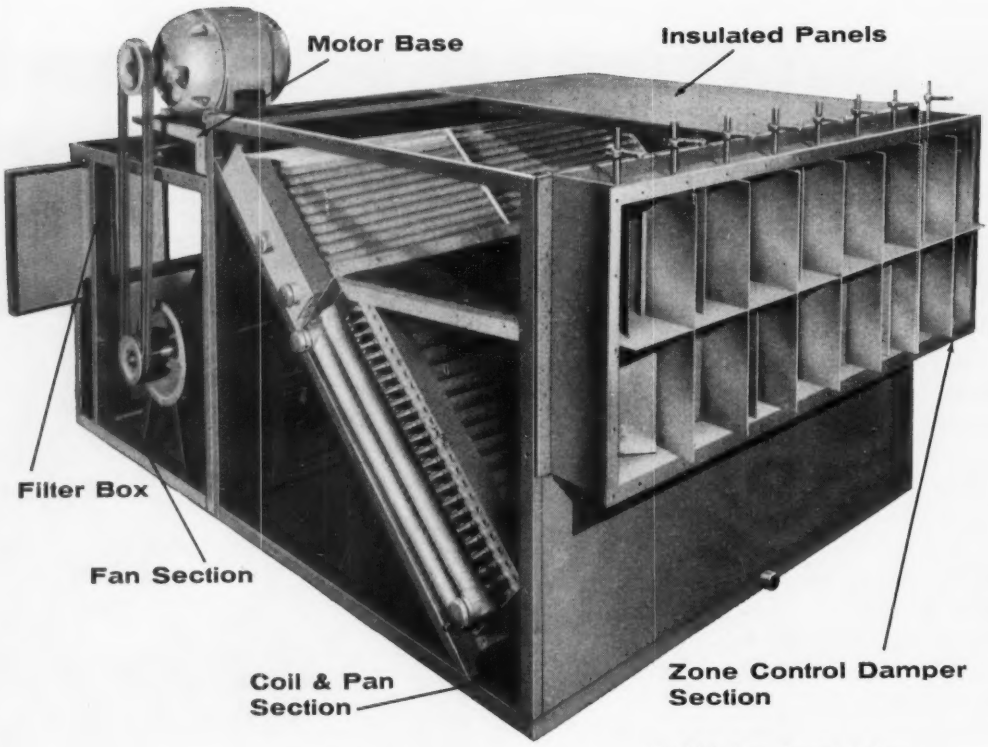
The gasket may be removed without damaging the sealing surface of the body. As the gasket is removed, the sealing surfaces separate freely without damage to gasket seat in body.

By inserting knock-out pin in drilled hole segmental thrust ring can be easily driven out of retaining groove.

The gasket seating surface in the body may be easily lapped, if required — an outstanding feature in Powell Pressure Seal Valve design.

THE WM. POWELL COMPANY • *Dependable Valves Since 1846* • **Cincinnati 22, Ohio**

For more facts circle 214 on Reader Service card, p 125



"Buffalo" Zone Control Cabinet

IN AIR HANDLING EQUIPMENT, "BUFFALO" ADDS DEPENDABILITY TO EFFICIENCY

You can *depend* on "Buffalo" heating, cooling, ventilating units to provide a long, maintenance-free life of efficient, economical operation. That's because all "Buffalo" equipment is ruggedly built with heavy-duty construction throughout. Housings and panels are made of heavy-gauge steel, carefully welded for maximum strength. Extra-heavy construction is used where stress is greatest.

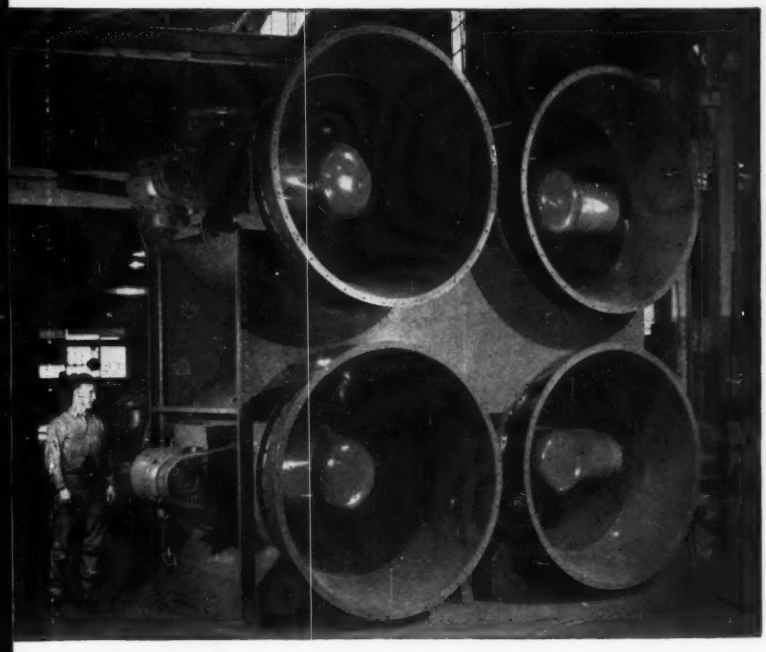
Oversized shafts and bearings are used for reserve strength under severe conditions. Shafts and fan wheels are factory balanced to insure minimum vibration. This further adds to higher efficiency and longer life. These are the reasons why many "Buffalo" fans and air conditioning units installed before the turn of the century are still "going strong".

For this same kind of dependable, economical, efficient air handling service, call in your nearby "Buffalo" engineering representative. Or write us direct for full information, including bulletins mentioned.

FOR INDIVIDUAL AREA COMFORT CONTROL. "Buffalo" Zone Control Cabinets, shown at left, are designed for installations where it is most economical to use a single unit to provide comfort conditioned air for several different areas. Temperature is controlled by mixing cooled and heated air from a single central source. Dampers regulate temperature to suit each conditioned space. Control for each area can be manual or automatic. Separate re-heat coils and their controls are eliminated.

These quiet, compact, efficient units are easy to assemble and install due to sectionalized construction. Heavy-gauge, corrosion-resistant components insure dependable, maintenance-free operation. Convenient access doors, removable panels and outside-located bearings simplify servicing.

"Buffalo" Zone Control Cabinets are available in many different combinations, for floor or ceiling installation. Extremely flexible, they can be adapted to any degree of heating, cooling and/or dehumidifying required. Write for Bulletin AC-220.

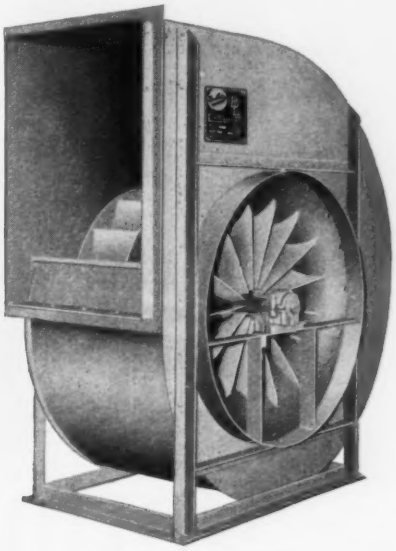


"Buffalo" Axials for Boiler Room Exhaust

FOR COMPACT INSTALLATION. Compact "Buffalo" Axial Flow Fans save space by hugging walls and ceilings. These rugged, reliable units serve as ventilation, exhaust and industrial air conditioning supply fans. Applications range from boiler room cooling to paint spray booth exhaust. Models are available for wide temperature ranges, corrosive fumes, explosive atmospheres.

Compact, lightweight "Buffalo" Axials are easily installed. No structural support or heavy foundation required, except for largest models. Quiet performance and high efficiency match economy of operation. Optional "Buffalo" Vane-axial outlet guide vanes convert swirling air at outlet into increased forward thrust. Write for Bulletin 3533-EF

FOR GENERAL AIR MOVING. The "Buffalo" Type "BL" Fan is a leading choice for large Class I and II ventilation, air conditioning and air cleaning systems. This fan is performance-proved for quiet, stable output from free delivery to shutoff. It is non-overloading through all pressure ranges. Minimum turbulence is the result of smoothly-curved inlet bell, directional guide vanes and matching shroud. Peak efficiency is assured by the streamlined wheel with backward-curved blades.



"Buffalo" Type "BL" Fan

Smooth air flow in the "BL" is further enhanced by the correctly shaped scroll of the wheel-contoured housing. Carefully built to Buffalo's rigid quality standards, the Type "BL" Fan is unsurpassed for reliability, economy and efficiency of operation. Write for Bulletin F-104.

Every "Buffalo" product brings you the famous "Q" Factor — the built-in QUALITY that provides trouble-free satisfaction and long life.

"Buffalo"

BUFFALO FORGE COMPANY

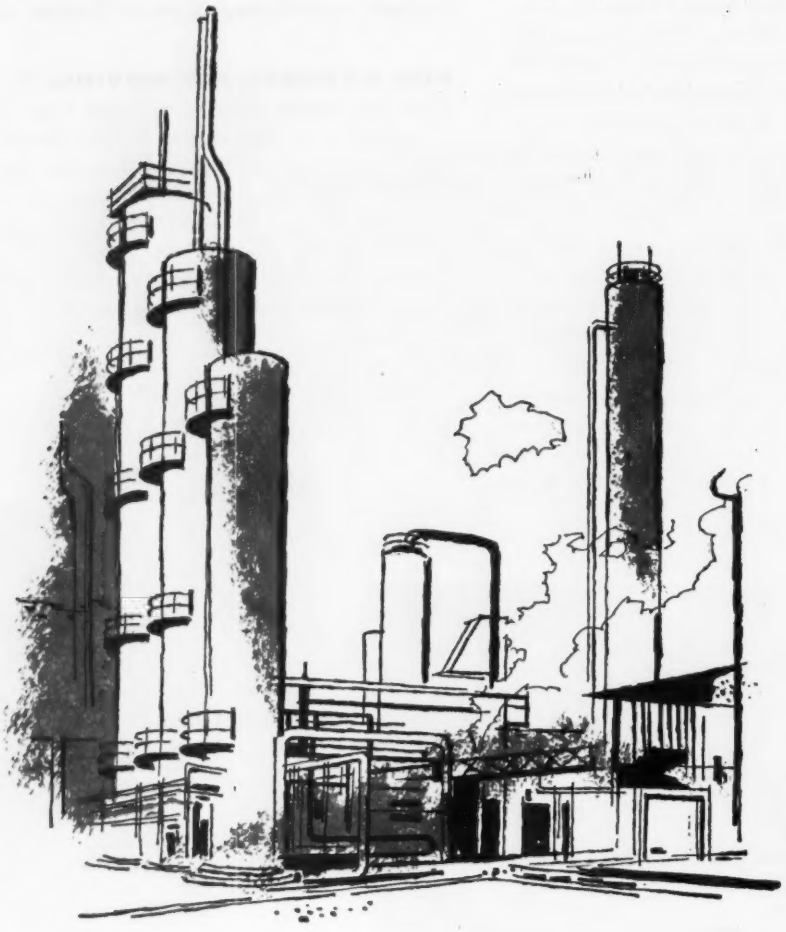
Buffalo, New York

Buffalo Pumps Division, Buffalo, New York

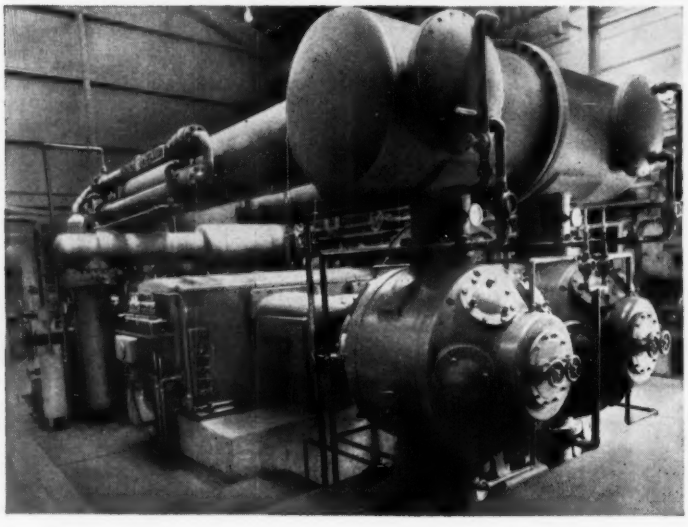
Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

VENTILATING • AIR CLEANING • AIR TEMPERING • INDUCED DRAFT • EXHAUSTING
FORCED DRAFT • COOLING • HEATING • PRESSURE BLOWING

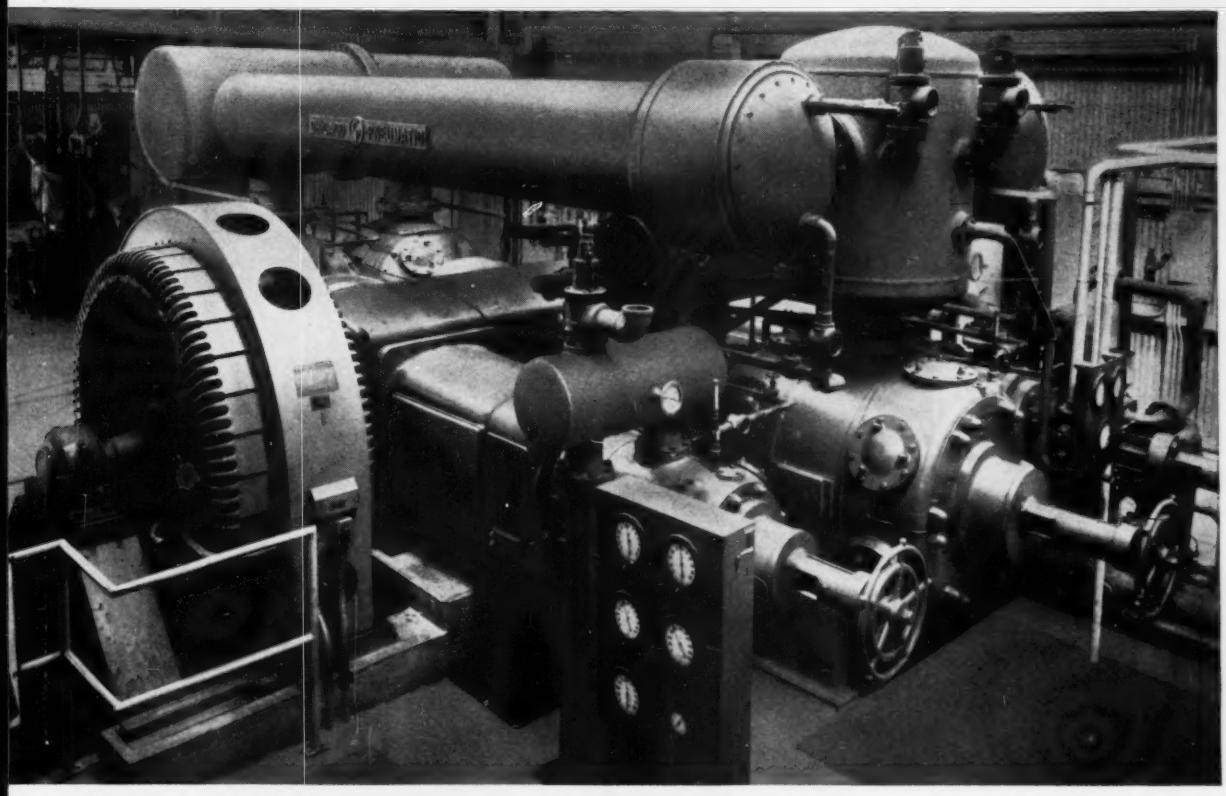
For more facts circle 215 on Reader Service card, p 125



CLASS WORKHORSE



Two views of a 2500hp, five-throw, five-stage Class FE Compressor installed in a large steel plant



FE COMPRESSORS FOR AIR LIQUEFACTION

Class FE horizontal, balanced-opposed compressors are doing an impressive job in the production of oxygen and in many other processes which demand compressors that take high pressures and heavy duty service in their stride. The "FE" is only one of many CP designs for such requirements. Horsepowers to 5000; pressures up to 15,000 pounds. Write for detailed specifications.

Chicago Pneumatic 8 East 44th Street, New York 17, N. Y.

AIR AND GAS COMPRESSORS • VACUUM PUMPS • PNEUMATIC TOOLS • ELECTRIC TOOLS • DIESEL ENGINES • ROCK DRILLS • HYDRAULIC TOOLS

For more facts circle 216 on Reader Service card, p 125

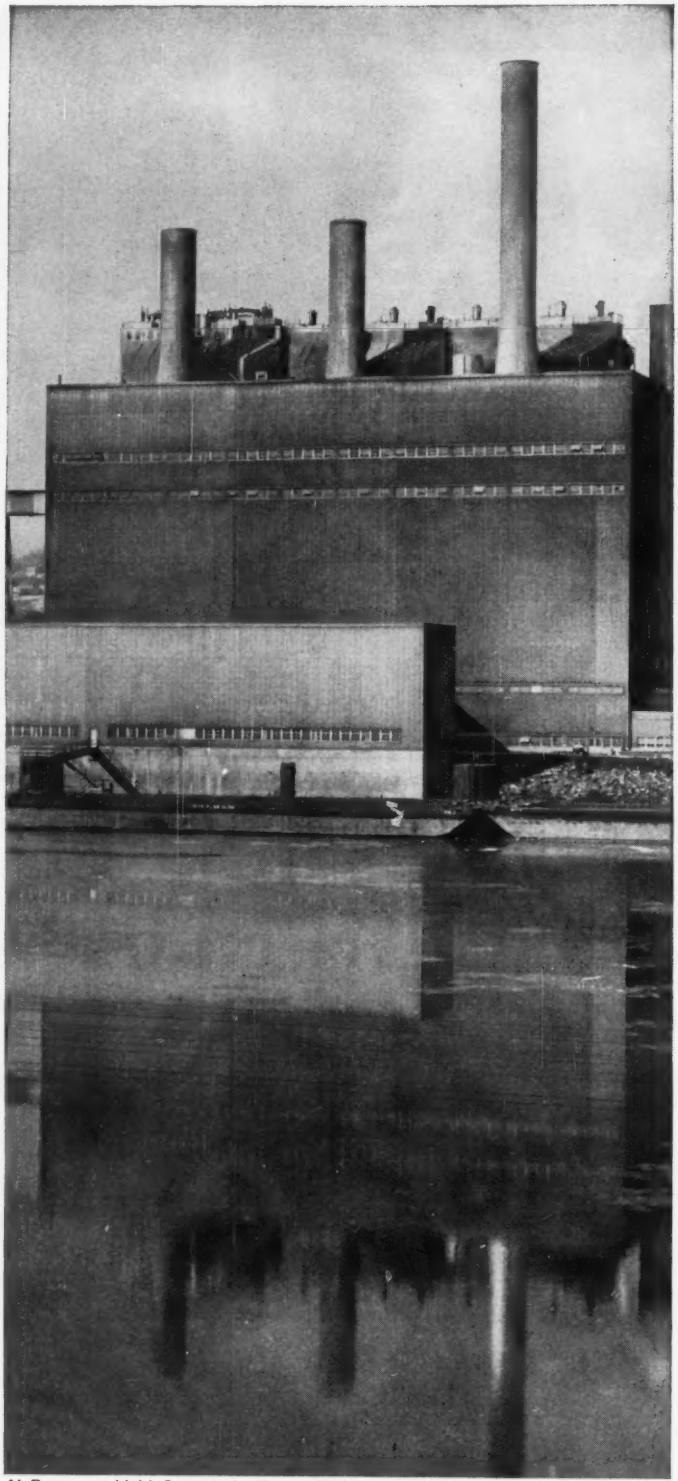
Lengthen stack life with corrosion-resistant concrete

Corrosion-resistant concrete linings, made with Lumnite calcium-aluminate cement and Haydite aggregate, will protect stacks and breechings from the corrosive action of condensate.

Such linings also provide insulation to keep stack gases hot, helping to maintain better draft for greater operating efficiency. The steel shell will be kept cooler, extending life of exterior paints. In addition, monolithic concrete linings have a lower unit weight, reducing the dead load on the supporting structure. Installation is easy, economical – by guniting or plastering. Concrete will reach service strength in 24 hours, reducing outage time.

For convenience, manufacturers of refractories offer castables bonded with Lumnite cement – packaged mixtures ready for use with just the addition of water. For more information, write Universal Atlas Cement, 100 Park Avenue, New York 17, N.Y.

"USS," "Atlas" and "Lumnite" are registered trademarks



At Duquesne Light Company's Elrama (Pittsburgh) Station, these steel stacks are being extended and then lined with corrosion-resistant concrete, made with Lumnite cement.

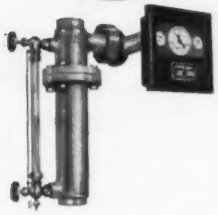
Universal Atlas Cement
Division of
United States Steel

L-109

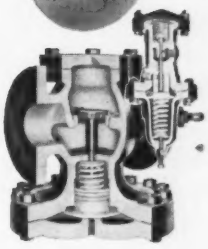
OFFICES: Albany · Birmingham · Boston · Chicago · Dayton · Kansas City · Milwaukee · Minneapolis · New York · Philadelphia · Pittsburgh · St. Louis · Waco

For more facts circle 217 on Reader Service card, p 125

SPLIT-BODY VALVES



LEVEL CONTROLLERS



PRESSURE REGULATORS

DIAPHRAGM CONTROL VALVES

KEEP A FIRM HAND ON FLUID CONTROL WITH K&M VALVES ALL ALONG THE LINE

From the complete display on the K & M shelf, you can select the best type of valve for every control job in the process line. You can, in fact, standardize entirely on K&M. That means simplified specification, ordering, maintenance.

Especially maintenance. K & M engineers have put consistent design emphasis on field interchangeability of components. In a pinch, you can "borrow" an inner valve or a topworks assembly from a pressure regulator for use with a diaphragm motor valve. That's what we mean by interchangeability.

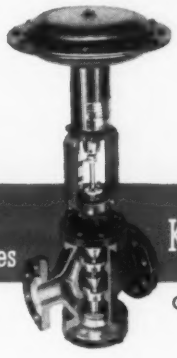
And because the K & M line is so diverse and inclusive, our field representatives are free to make unbiased suggestions on the type of valve best suited to your requirements. That can often mean substantial dollar savings all along the process line.

THREE TECHNICAL BULLETINS GIVE THE IMPORTANT FACTS AND FIGURES. THEY'RE YOURS FOR THE ASKING.

Bulletin 401 Pressure-Regulating Valves

Bulletin CV53 Standard Diaphragm-Operated Control Valves

Bulletin 132 Split-Body Valves



K&M

diaphragm control valves

KIELEY & MUELLER, INCORPORATED

Our 79th Year

Oldest Pressure and Level Control Valve Manufacturer

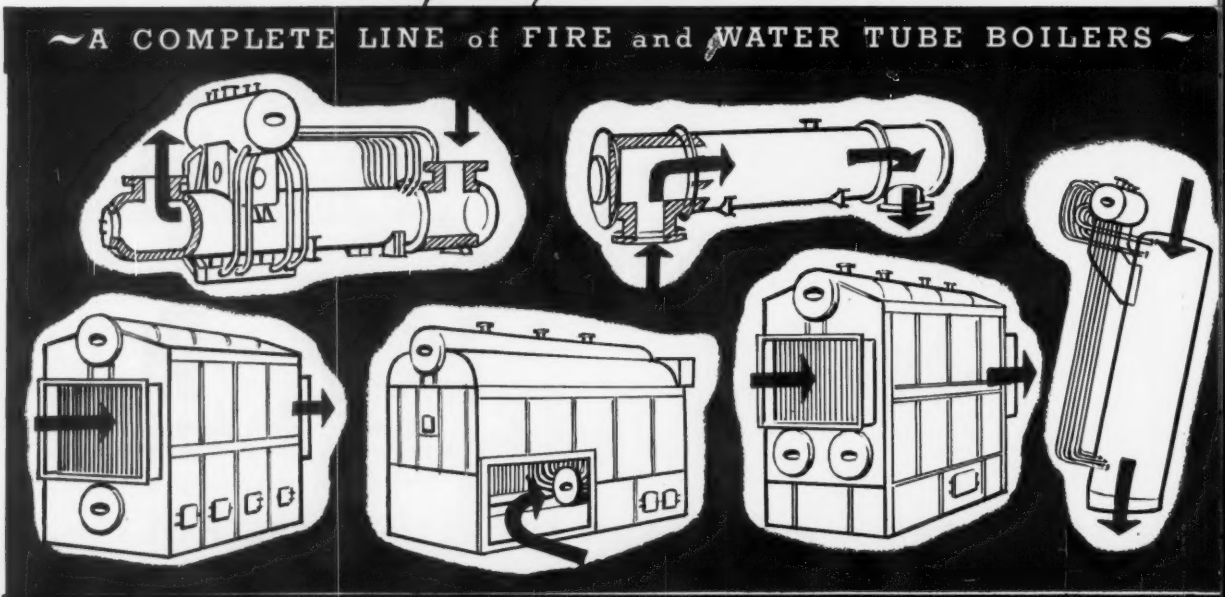
64 Genung Street, Middletown, New York

S.A. 1721

For more facts circle 218 on Reader Service card, p 125

Erie City HAS WHAT IT WASTE

~A COMPLETE LINE of FIRE and WATER TUBE BOILERS~



~USING THESE PROCESS GASES~

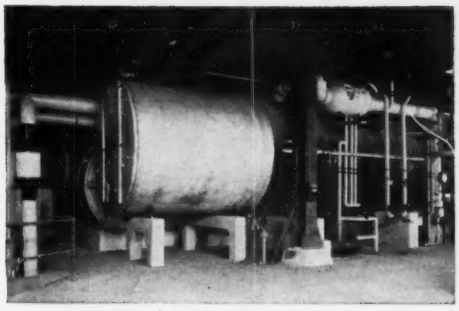
BLACK LIQUOR GAS • OPEN HEARTH GAS • INCINERATOR GAS
REFORMED GAS • ZINC ROASTER GAS
SODIUM SILICATE GAS • REVERBERATORY GAS • SO_3 GAS
NITRIC ACID GAS • GAS TURBINE EXHAUST

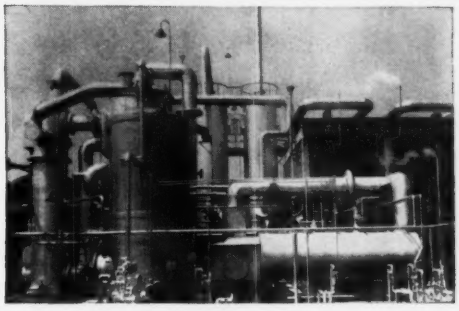
~AT THESE LEADING PROCESSING COMPANIES~

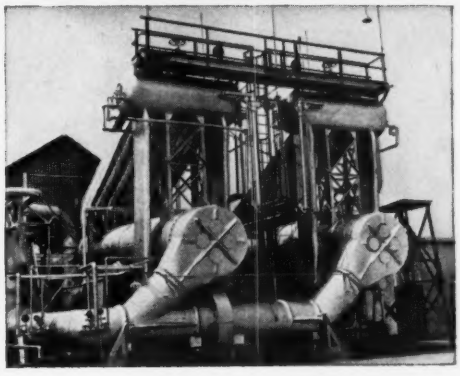
Adams Terminal Ammonia Co.
Advance Bag & Paper Co.
Allied Chemical & Dye Corp.
Allis Chalmers Mfg. Co.
American Cyanamid
American Oil Co.
American Rolling Mill
American Smelting & Refining Co.
Atmospheric Nitrogen Co.
Bethlehem Steel Corp.
Blaw Knox Corp.
Brea Chemicals, Inc.
Central Iron & Steel Co.
Chemical Construction Co.
City of Bridgeport, Conn.
Commercial Solvents Co.
Consolidated Chemical Co.
Continental Oil Co.
Diamond Alkali Co.
DuPont Co.
Eagle Pitcher Co.
Eastman Kodak Co.
General Chemical Co.
Gulf Oil Corp.
Jersey City Incinerator
Lion Oil Co.
Lowell Gas & Electric Co.
New York & Pennsylvania Co.
Olin Mathieson Chemical Corp.
Philadelphia Gas Co.
Reichold Chemicals
Shamrock Oil & Gas Co.
Sherritt Gordon Mines Ltd.
Southern Kraft Corp.
St. Helens Pulp & Paper Co.
Stauffer Chemical Co.
Texas Eastman Co.
Tidewater Associated Oil Co.
Union Bag & Paper Power Corp.
Union Oil Co.
West Virginia Pulp & Paper Co.

TAKES FOR EFFICIENT----

HEAT RECOVERY







Two factors combine to make Erie City Iron Works your reliable headquarters for specialized applications of waste heat recovery systems. - - - First, is our eagerness to cooperate with Process Engineers - - - whether the problem is routine or highly involved. As a result, we have gained valuable experience in waste heat recovery for modern processing that is unequaled in the steam generating field. - - - Second, Erie City Engineers have available a complete line of standardized fire- and water-tube boilers and the know-how to apply them to meet specified conditions. Erie City Waste Heat Recovery Systems are being used with all kinds of gases throughout the broad field of processing. We welcome the opportunity to work with your engineers on any waste heat recovery problem, or for that matter any steam generating problems.

Write for our comprehensive bulletin SB-6091F.

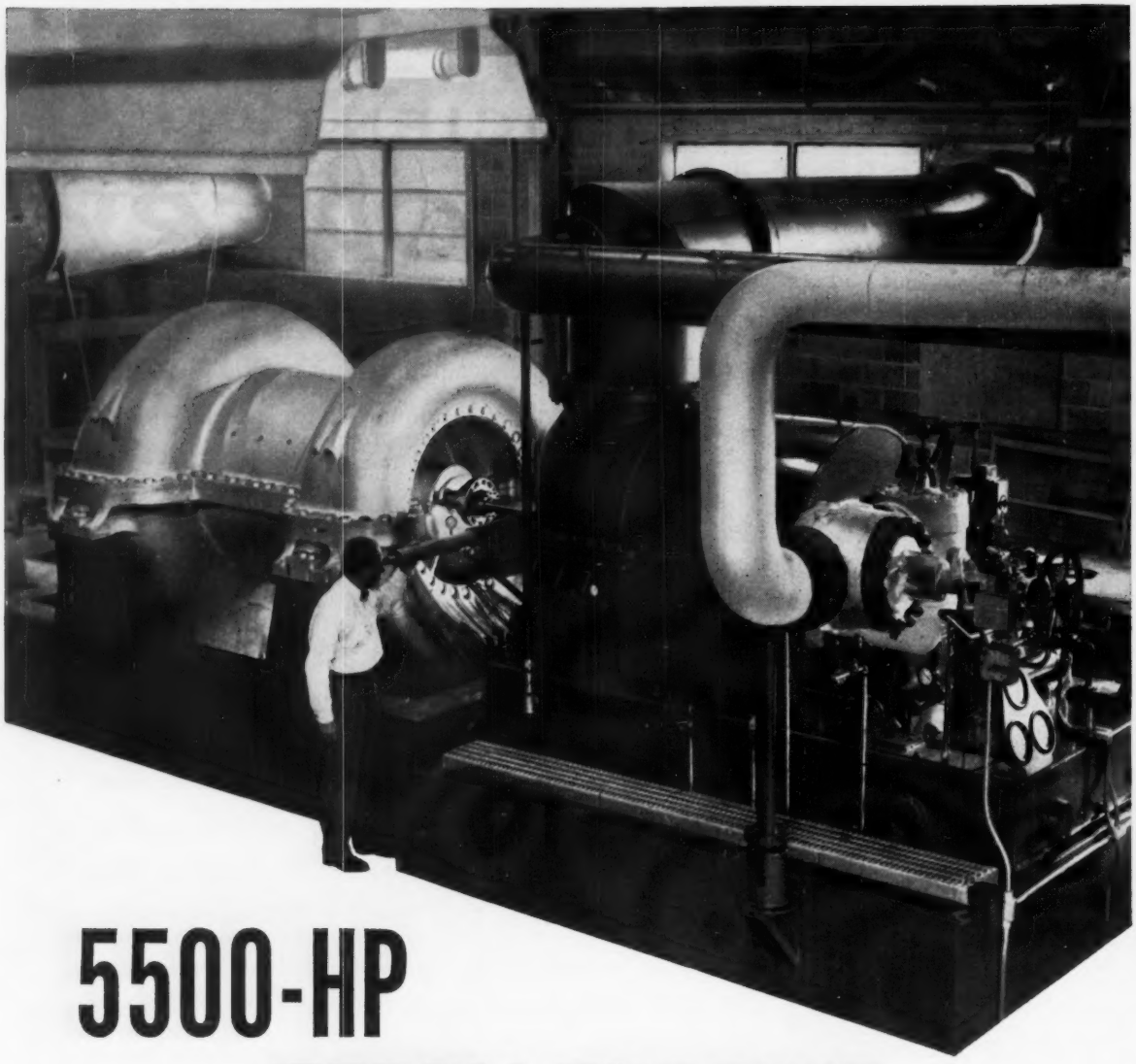
You can depend on Erie City for sound engineering

ERIE CITY IRON WORKS · Erie, Pa.

•STEAM GENERATORS •SUPERHEATERS
•ECONOMIZERS •AIR PREHEATERS
•WASTE HEAT BOILERS •FIRE AND WATER TUBE PACKAGE BOILERS
OIL AND GAS BURNERS • STOKERS • PULVERIZERS

ERIE CITY Since 1840

For more facts circle 219 on Reader Service card, p 125



5500-HP TERRY TURBINE

plays an important role in compressor testing at Joy

Joy Manufacturing Company puts Terry high-speed turbine reliability to good use in its development facility at Buffalo, New York. This 5500-hp multistage turbine is used for testing centrifugal and axial-flow compressors. It provides speeds up to 9,000 rpm.

The long, trouble-free life of Terry high-speed turbines stems from two sources: (1) more than 50 years of successful experience in making turbine drives *exclusively*, (2) a willingness to build *something extra* into each machine to assure its reliability.

There's a reliable Terry turbine for you in sizes up to 6000 hp. In special cases higher outputs can be supplied.

For more information about Terry multistage turbines, ask for a copy of bulletin S-146.

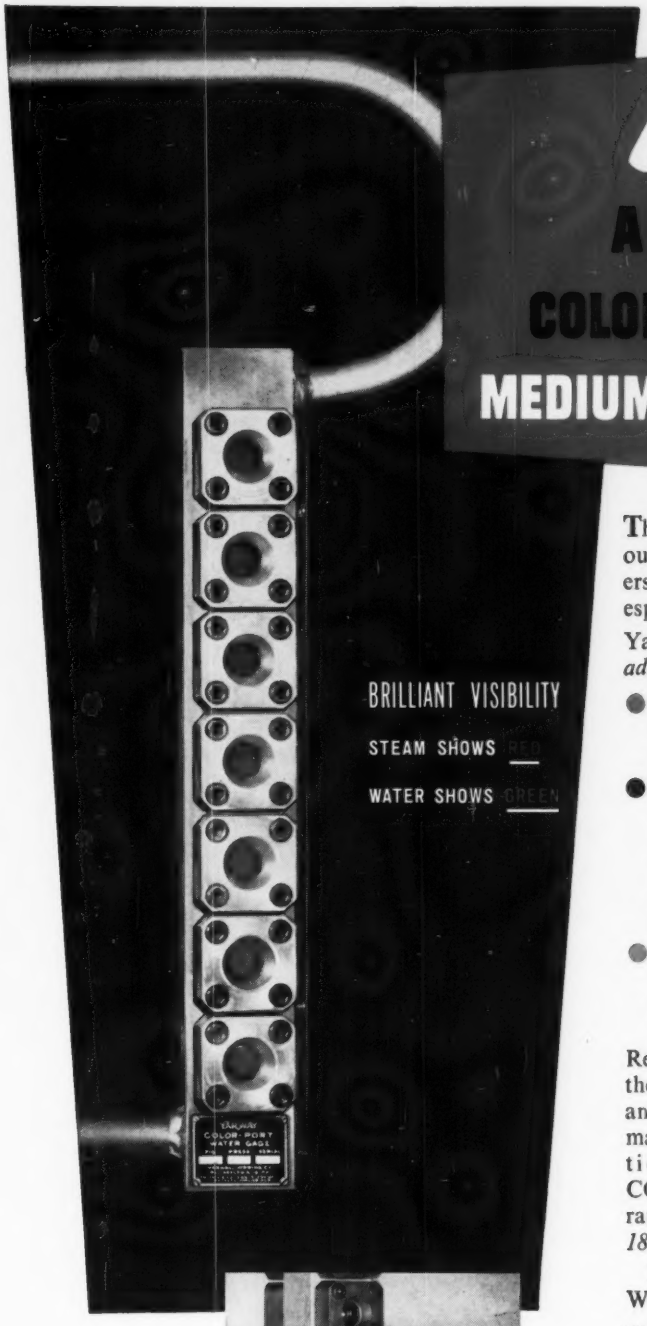
TERRY

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD 1, CONN.

TT-1215

For more facts circle 220 on Reader Service card, p 125

NEWS FROM YARWAY



now!

A NEW YARWAY COLOR-PORT GAGE FOR MEDIUM PRESSURE BOILERS

The Yarway Color-Port Water Level Gage, so outstandingly successful on high pressure boilers, is now available in a new model designed especially for boilers operating up to *1050 PSI.*

Yarway Color-Port gives you all these *triple advantages:*

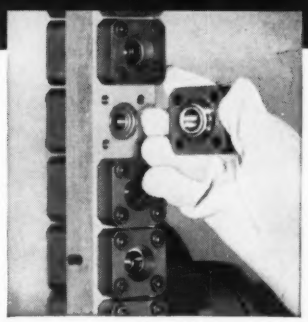
- *Two color readings*, brilliant and clear. Water shows green; steam shows red. A full gage is all green; an empty gage all red.
- *Low maintenance.* Servicing the Color-Port is simple as A-B-C. With gage remaining in place, individual cover plate assemblies can be inserted in a matter of minutes. Exclusive spring loading maintains proper pressure on glasses and gaskets at all times.
- *Increased operational time.* Yarway Color-Port Gages assure longer operational life, with a minimum of "time out" for maintenance.

Replace troublesome water level gages with the new medium pressure Yarway Color-Port—and for your new boilers, make sure the specifications read YARWAY COLOR-PORT. Visibility ranges of *13"*, *15½"* and *18"* available.

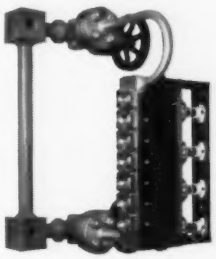
Free descriptive Bulletin WG-1815 on request.

YARNALL-WARING COMPANY
145 Mermaid Avenue,
Philadelphia 18, Pa.

BRANCH OFFICES IN PRINCIPAL CITIES



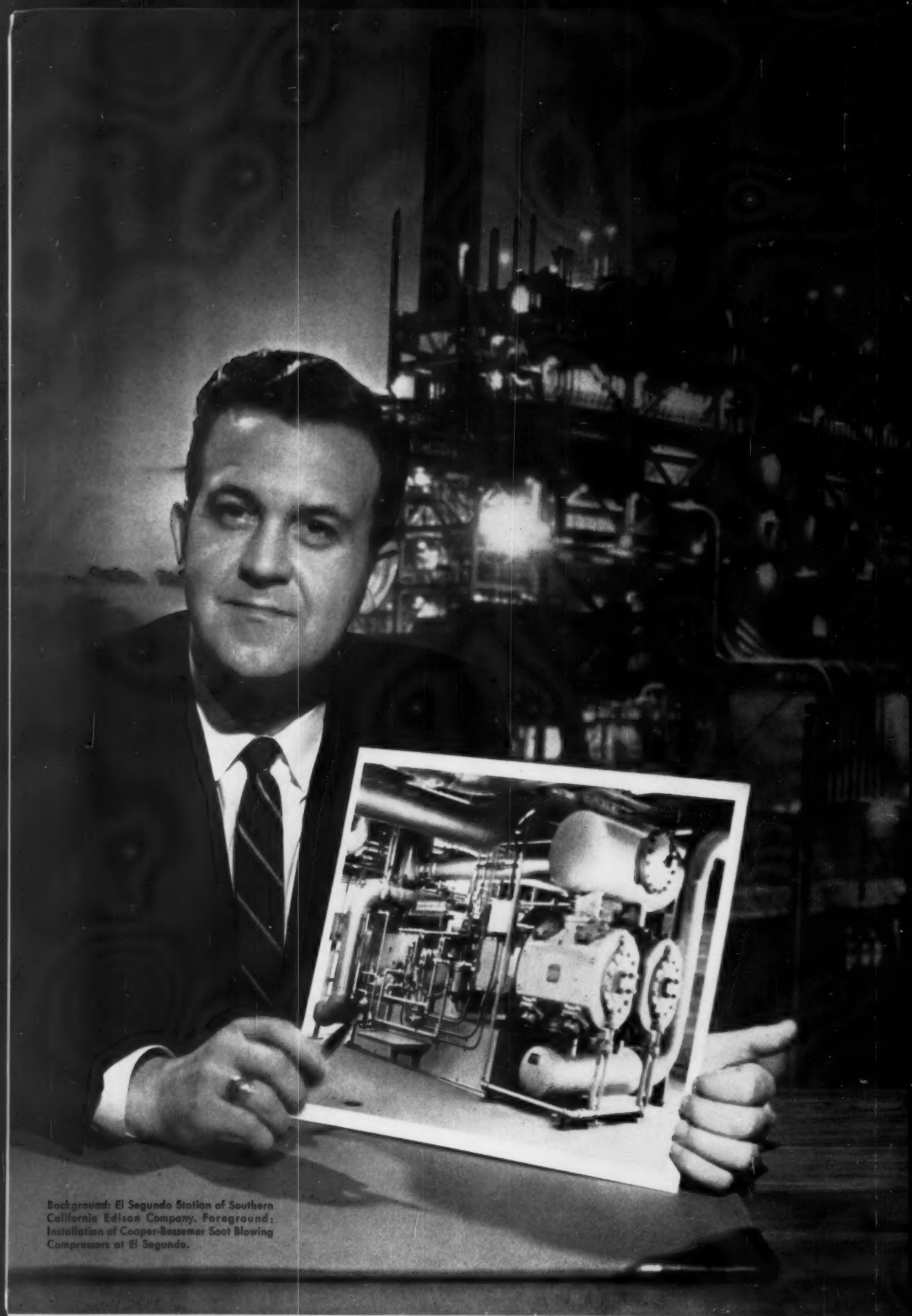
Complete cover plate assemblies can be replaced in minutes, with the gage in place.



Complete Color-Port assembly, with tie-bar column, Welbond Gage Valves and Yarway Illuminator.

YARWAY®

For more facts circle 221 on Reader Service card, p 125



Background: El Segundo Station of Southern California Edison Company. Foreground: Installation of Cooper-Bessemer Soot Blowing Compressors at El Segundo.

Dann Goodson, *Manager Motor-Driven Compressor Sales, The Cooper-Bessemer Corporation, explains...*

How soot blowing with air increases power plant efficiency

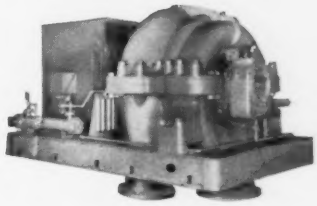
POWER PLANTS are switching from steam to compressed air for cleaning of furnaces and tube banks because they can *reduce costs*. The new way, with Cooper-Bessemer compressors, has these important advantages:

1. **Pressure is always adequate to do clean, thorough job.**
2. **Better programming with air... gets better cleaning results for higher boiler efficiency.**
3. **Lower initial cost, lower operating cost, and hence lower cost for blowing medium... less waste.**
4. **No quenching action on hot alloy tubes or pressure vessels.**
5. **Less maintenance of blower equipment due to erosion, corrosion, packing wear.**
6. **Improved housekeeping... no steam or condensate leakage.**
7. **Greater over-all economy of blowing medium on evaluated basis.**
8. **Eliminates condensate makeup required when blowing with steam.**

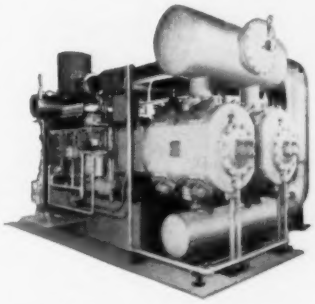
You can find out more about this by writing for a copy of the article reprint, "Steam or Air: Which costs more for boiler cleaning?" We would be glad to help you in planning your compressor facilities for soot blowing... or other power plant uses. Call the office near you.

BRANCH OFFICES: Grove City • New York • Washington • Gloucester
Chicago • Minneapolis • St. Louis • Kansas City • Tulsa • New Orleans
Shreveport • Houston • Greggton • Dallas • Odessa • Pampa • Casper
Seattle • San Francisco • Los Angeles

SUBSIDIARIES: Cooper-Bessemer of Canada, Ltd.... Edmonton
Calgary • Toronto • Halifax
C-B Southern, Inc.... Houston
Cooper-Bessemer International Corporation... New York • Caracas
Mexico City



Direct motor-driven multi-stage centrifugal compressor. Sizes of 3000 cfm free air and up.



Multi-stage reciprocating compressor. Sizes up to 30,000 cfm free air.

Cooper Bessemer

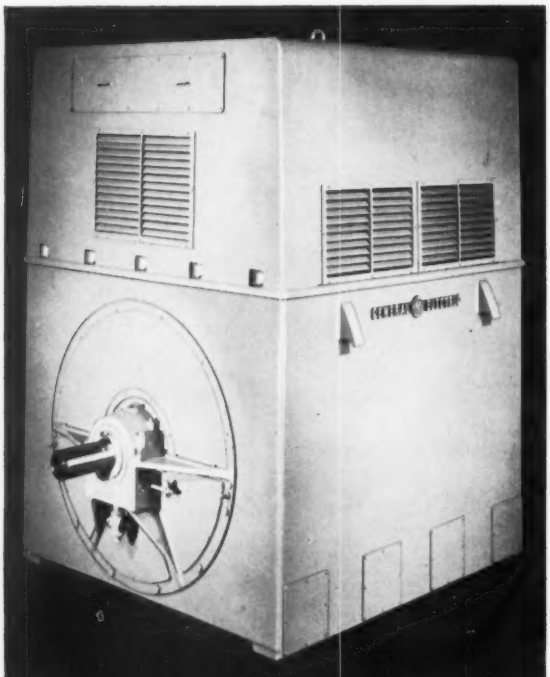
GENERAL OFFICES: MOUNT VERNON, OHIO

ENGINES: GAS - DIESEL - GAS-DIESEL
COMPRESSORS: RECIPROCATING AND CENTRIFUGAL
ENGINE OR MOTOR DRIVEN

For more facts circle 222 on Reader Service card, p 125

FROM GENERAL ELECTRIC . . .

New Custom-designed Power Station Motors Provide Better Protection, Easy Maintenance



ALL-NEW G-E WEATHER PROTECTED MOTORS exceed NEMA Type II definition, give better protection against rain, snow, even hurricanes.

Now, you can get a new General Electric motor custom-designed for your specific power station requirements. Nine custom-designed enclosures—eight custom-designed insulation systems—seven custom-designed bearing and end shield constructions—more than 15 custom-designed accessories—and a countless number of electrical designs: these give our engineers freedom to create a power station motor that can meet your exact needs. General Electric's all-new weather protected motor, shown at left, is one example of how a motor can be custom-designed for its particular application.

CUSTOM-DESIGNED FOR BETTER PROTECTION—Unique labyrinth baffling system of new weather-protected motor forces incoming air to make a series of right-angle turns and reductions in velocity before entering motor. And, special "blow-through" passages give extra protection against high-velocity winds.

CUSTOM-DESIGNED FOR EASY MAINTENANCE—New end shield is lightweight, easy to remove and disassemble, eliminating need for crane or lifting rig. Vistamatic sight gages are located on top and both sides allowing oil ring observation and easy reading of oil level.

CUSTOM-DESIGNED FOR GREATER ACCESSIBILITY—Removable top section provides access to all air passages and baffles for easy inspection, maintenance. Motor windings and bearings are easy to reach because of new end shield which is lightweight and easily removed.

FOR MORE INFORMATION on General Electric custom-designed power station motors, contact your nearby G-E Apparatus Sales Office or write to Section 884-1, General Electric Co., Schenectady, N.Y.

GENERAL ELECTRIC

TOP ACCESSIBILITY—Air passages in top section are completely accessible through nine openings. Filter installation or inspection is fast and easy.

BETTER PROTECTED AIR OPENINGS—"High up" air intake passages of new G-E motor prevent snow, trash, dust or dirt from being drawn into the motor.

SIMPLIFIED MAINTENANCE—Removable, lightweight end shield permits complete accessibility to motor interior, bearings without disturbing alignment.

For more facts circle 223 on Reader Service card, p 125

5 years of operation at the Possum Point Power Station of...

VIRGINIA ELECTRIC and POWER COMPANY

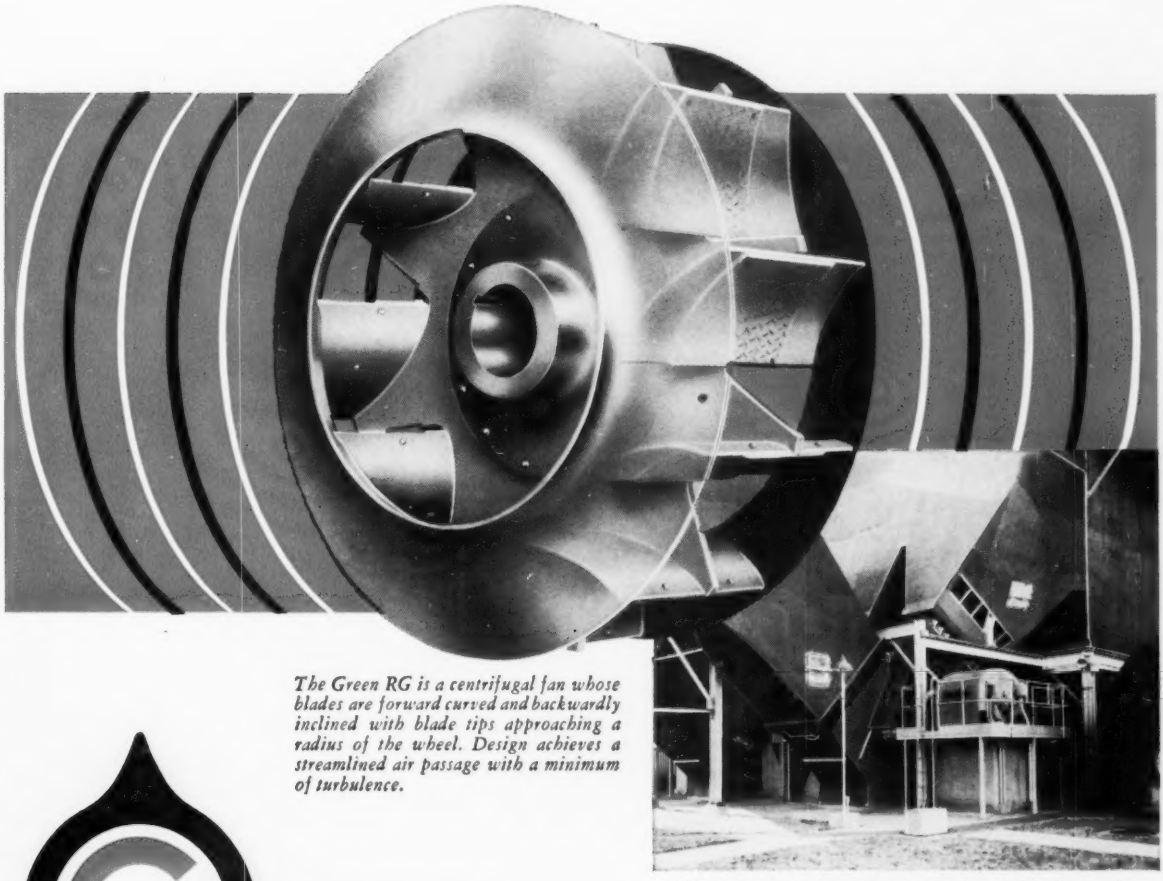
With Green RG Fans, of course.

Somehow, you just expect Green fans to give years of trouble-free operation.

When Virginia Electric and Power Company planned their Possum Point Power Station, with Stone & Webster consulting, they selected Green RG Fans for both induced and forced draft.

Green RG Fans are rugged, reliable, self-cleaning and accessible.

When you want trouble-free fan performance — consult Green.



The Green RG is a centrifugal fan whose blades are forward curved and backwardly inclined with blade tips approaching a radius of the wheel. Design achieves a streamlined air passage with a minimum of turbulence.

This is the induced draft Green RG Fan installation at the Possum Point Power Station. ¼" housing and inlet boxes. ½" scroll liners. Diamond checkered floor plate blade liners. Air-cooled, self-aligning sleeve bearings. 600 HP, 880 RPM motors.

Green

THE GREEN FUEL ECONOMIZER CO., INC. BEACON 3, NEW YORK

For more facts circle 224 on Reader Service card, p 125

ENERGY

for an Ohio Valley colossus

generated with the help of Socony Mobil!

1. Consolidation Coal Company's mine shaft and installation

2. American Electric's Kammer power plant

This 11-mile section of Ohio Valley is a creation of men of vision. Their careful planning and willingness to invest in their own ideas resulted in a vast industrial complex . . . a private capital investment of over one-quarter billion dollars.

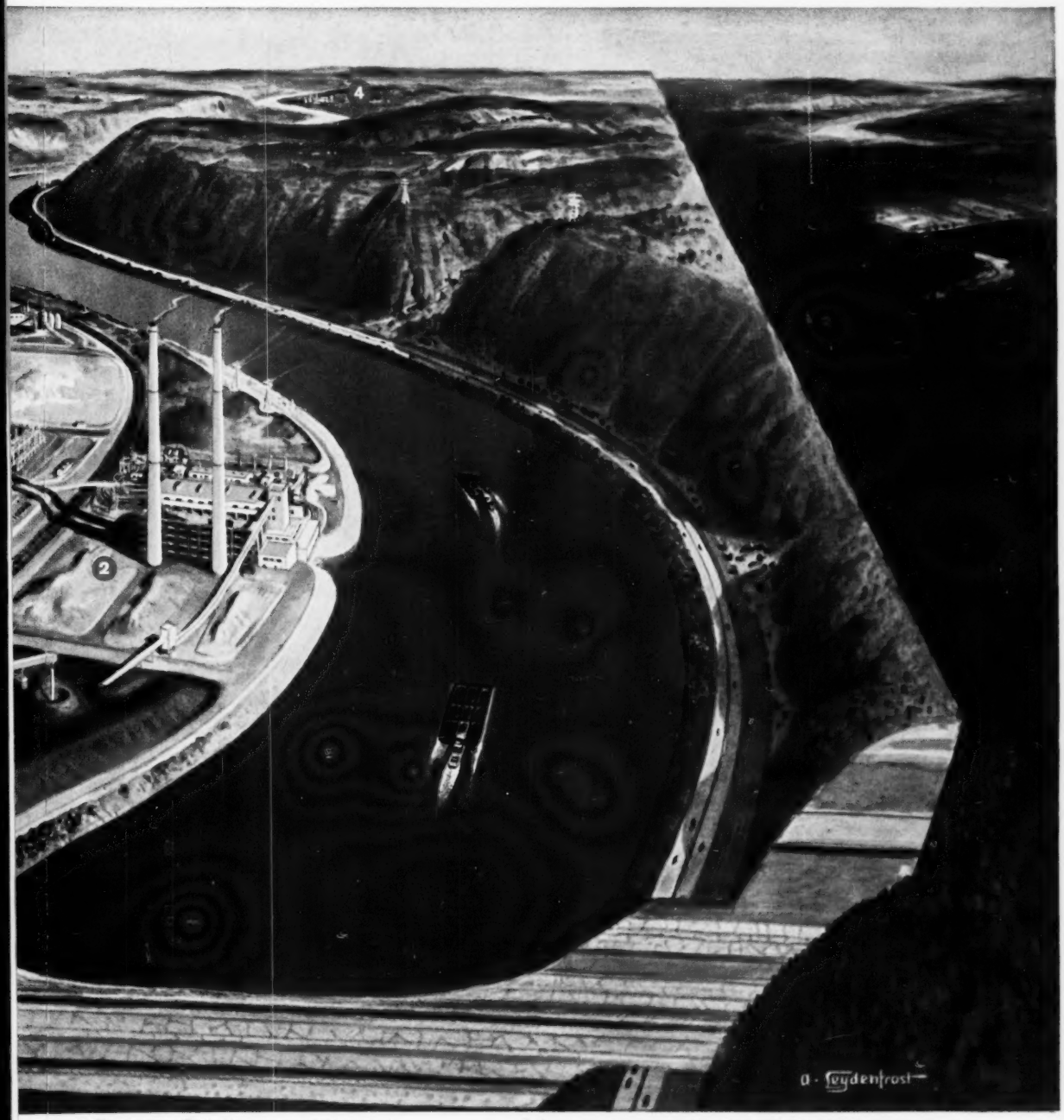
Energy center for this fuel-to-power-to-metal integration is the giant Kammer plant at Cresap, W. Va., jointly owned by the American Electric Power System and Ormet Corporation. Low-cost power is generated from coal mined below in Consolidation Coal Company's huge development. Power is transmitted 11 miles down the river to serve Ormet Corporation's aluminum reduction plant and Olin Mathieson Chemical Corporation's aluminum rolling mill near Clarington, Ohio.

Mobil petroleum products *exclusively protect* the power generation and aluminum reducing phases of this complex. Here is another example of how leaders of industry look to Mobil. The reason? An exceptional ability to assure continuous production . . . to help keep maintenance costs at a minimum, profits at a maximum. Why accept less for your plant?

Mobil

Mobil Correct Lubrication

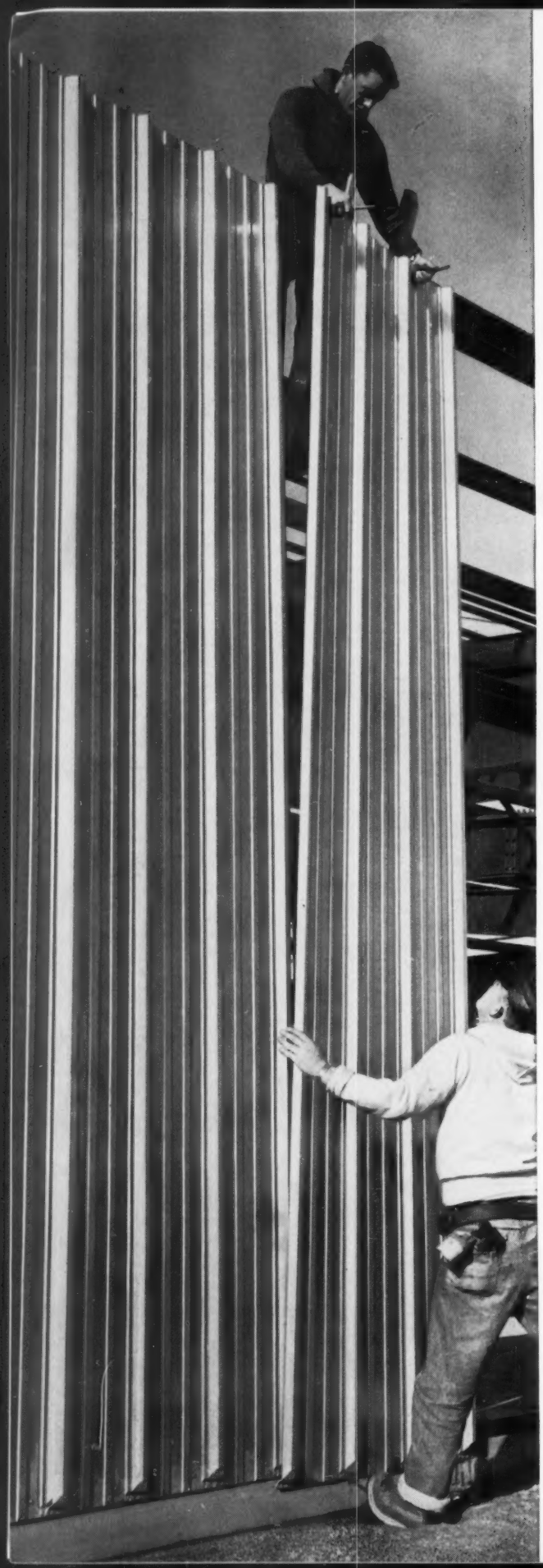
Another reason you're Miles Ahead with Mobil!



3. Mountaineer Carbon's coke processing plant

4. Ormet aluminum reduction plant and Olin Mathieson rolling mill

For more facts circle 225 on Reader Service card, p 125



New **Butlerib**™ *panels** *create the*

BOLD AND BEAUTIFUL LOOK

for Butler buildings

Butlerib—a bold new metal building panel—so beautiful, you'd expect to find it only on expensive custom-fabricated structures.

Butlerib's unique combination of deep and shallow corrugations creates pleasing shadows . . . gives industrial and commercial buildings a substantial, distinctive appearance. Yet, it's the new standard cover on Butler buildings—the lowest-cost way to build well.

Butlerib's new corrugated pattern creates a stronger, more rigid panel. This means there's less deflection under wind and snow loads . . . joints *stay* tight. The result—the strongest . . . most weathertight cover ever offered as standard construction on any pre-engineered buildings.

Butlerib roofs give maximum protection, yet never require re-roofing, re-waterproofing, or other costly maintenance procedures.

A full 3 feet wide, in lengths up to 32 feet, Butlerib panels make short work of covering even the largest Butler buildings.

Now . . . more than ever before—Butler is the fastest . . . lowest-cost way to build well. Butler pre-engineering and factory fabrication cuts weeks—even months—from costly building schedules. This puts you in business, earning profits, far sooner than slow, traditional or ordinary building methods.

Get the full story of the Butler system of building from your nearby Butler Builder. Ask him about Butler financing too. He's listed in the Yellow Pages under "Buildings" or "Steel Buildings." Or, write directly to us.

*Patent Nos. D178605; D178659

BUTLER®

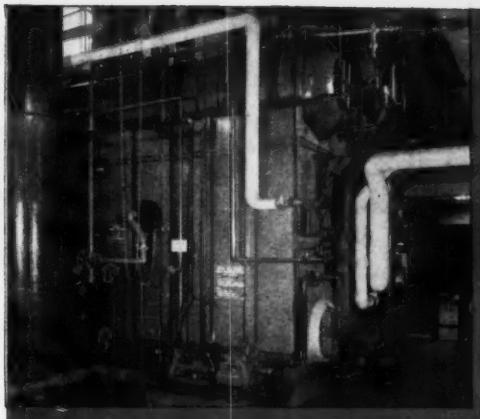
BUTLER MANUFACTURING COMPANY

7530 East 13th Street, Kansas City 26, Missouri

Manufacturers of Metal Buildings • Equipment for Farming, Dry Cleaning, Oil Production and Transportation, Outdoor Advertising • Contract Manufacturing

Sales offices in Los Angeles and Richmond, Calif. • Houston, Tex. • Birmingham, Ala. • Kansas City, Mo. • Minneapolis, Minn. • Chicago, Ill. • Detroit, Mich. Cleveland, Ohio • Pittsburgh, Pa. • New York City and Syracuse, N.Y. • Boston, Mass. Washington, D. C. • Burlington, Ontario, Canada

For more facts circle 226 on Reader Service card, p 125



A 15,000 lbs/hr unit in a backyard plant

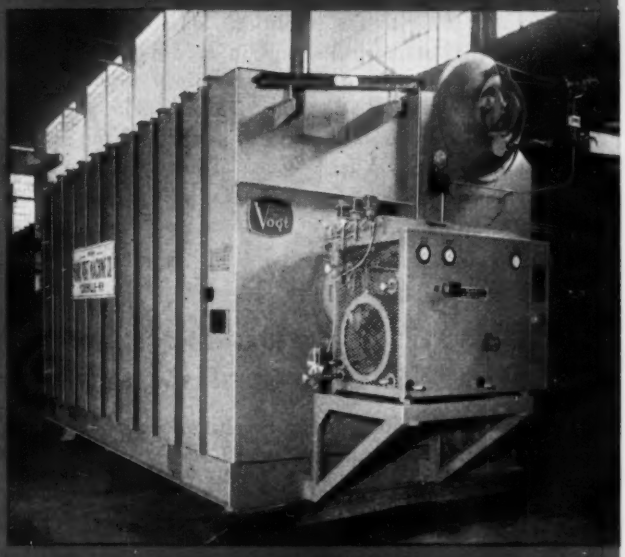
Boilers in various stages of completion in our shop

More Steam per dollar of investment with Vogt

PACKAGE WATER TUBE BOILERS

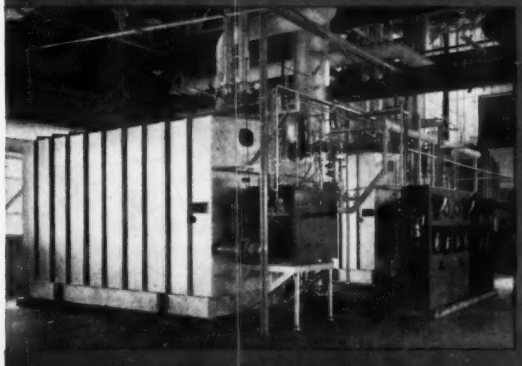
Completely shop fabricated, with burners, controls and accessories installed before shipment.

Placed on a suitable foundation, only fuel, water, breeching and steam connections need to be made to place unit in operation. Vogt Package boilers are available in oil and/or gas fired types in standard pressures of 175, 250 and 375 pounds per square inch gage.



One of two 30,000 lbs/hr units for a hospital

This 18,000 lbs/hr unit is one of two for an office building



Two 25,000 lbs/hr units installed in a manufacturing plant

Write for literature Address Dept. 24A-BP

HENRY VOGT MACHINE CO.
LOUISVILLE, KENTUCKY

SALES OFFICES: New York, Chicago, Cleveland, Dallas, Camden, N. J., St. Louis, Charleston, W. Va., Cincinnati

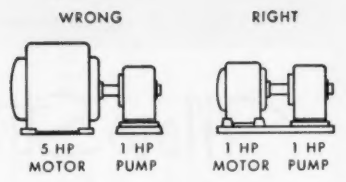
For more facts circle 227 on Reader Service card, p 125

Circle 228 on Reader Service card, for Following Ad ➤

Tips on evaluating Electrical

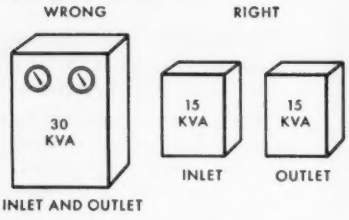
Matched Electrical Sets

You wouldn't use a 5 h.p. motor to run a pump that required only one h.p. Similarly, electrical sets should be *matched* to the requirements of the specific job. Electrical sets should be sized according to gas conditions, dust conditions, and other operating characteristics, and in accord with manufacturers' past experience on similar installations. *Don't be misled by high KVA ratings on the electrical sets.* The precipitator will only absorb a certain amount of power and the sets should be sized accordingly. A large excess of installed power, which will never be used, means inefficient use of the equipment.



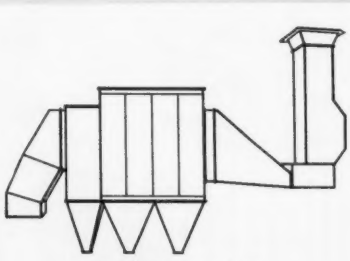
Varied Electrical Conditions

Electrical conditions in a precipitator can vary widely at different parts of the precipitator. For instance, a high voltage, low current condition usually prevails at the inlet where the dust load is high, as compared to a lower voltage higher current condition at the outlet. Consequently, it is good design (and a necessity for high efficiency) to furnish several electrical sections in series, with energization from separate electrical sets so that each section can be adjusted to best suit the conditions.



Gas Distribution

Remember that gas distribution, gas baffling, and provision against hopper sweeping all have a large influence on collection efficiency. The gas flow system should be analyzed as closely as possible, both in the precipitator and in the associated ductwork. If in doubt, have a three-dimensional gas flow study made. Two-dimensional gas flow studies *are not as accurate* and may lead to erroneous conclusions.

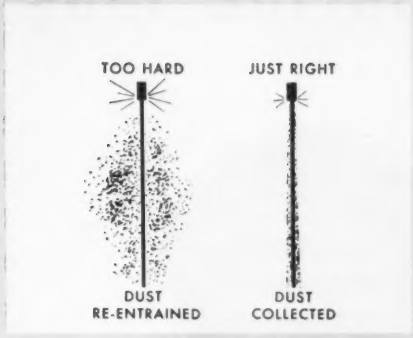


RESEARCH

RESEARCH-COTTRELL, INC. Main Office and Plant: Bound Brook, New Jersey

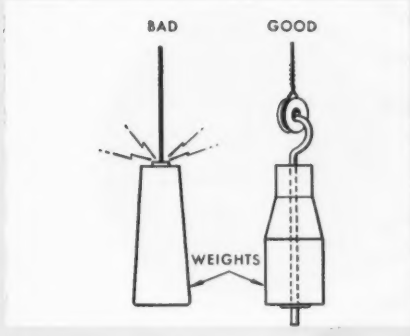
Precipitators

Some helpful hints to aid in selecting a properly designed unit



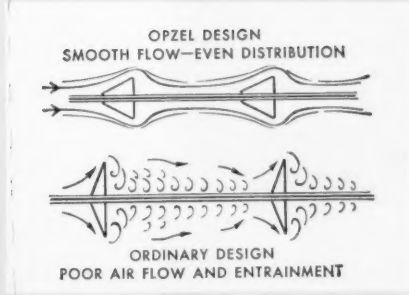
Rapping Intensity

Rappers should have easy means to vary the intensity of the blow to suit variations in operating conditions. A pre-set intensity setting cannot possibly give proper rapping over the normal range of operation. If too soft, build-up will occur which will disturb electrical conditions. If too hard, there will be reentrainment. Means of intensity adjustment are necessary to avoid drop-off of precipitator efficiency as conditions change.



Corona Discharge

It is a relatively easy matter to obtain a corona discharge in an electrostatic precipitator. Many types of discharge electrodes have been used over the past forty years, including ribbons, squares, twisted squares, star shaped sections, coiled wires, wires with prongs and projections, most of which give entirely adequate corona conditions. Final choice then gets down to mechanical factors such as strength of wire, method of support to avoid stress points, and ease of handling. There are many claims made for various types of wires but after investigating and testing hundreds of different kinds, we find a straight round wire about .1" diameter to be best.



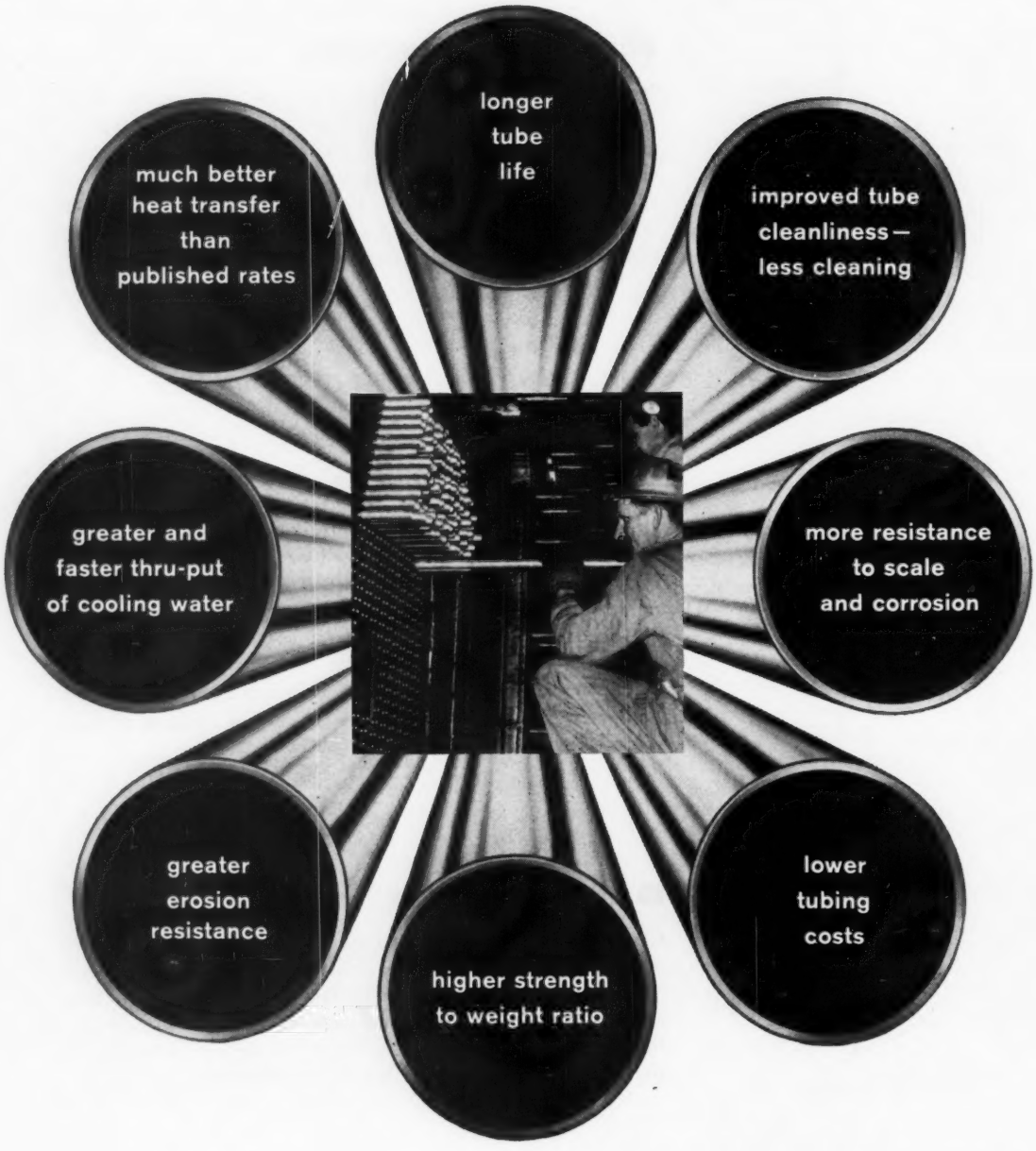
Baffle Design

Careful attention to the design of baffles on the collecting plates is most important. Small amounts of reentrainment mean tremendous differences in over-all collection efficiencies. It is seen that the "quality" of the collecting surface is far more important than quantity — quantity (sq. ft. of surface or treatment time) in itself is not a criterion of performance.

-COTTRELL

Representatives in all major cities of U.S. and Canada

Have you investigated the *Carpenter* lightwall


longer tube life
improved tube cleanliness—less cleaning
more resistance to scale and corrosion
lower tubing costs
higher strength to weight ratio
greater erosion resistance
greater and faster thru-put of cooling water
much better heat transfer than published rates

proved benefits of stainless tubing for your surface condensers?

Tests recently conducted at a large eastern power plant *prove* that Carpenter's lightwall stainless tubing handles greater throughput of cooling water at higher velocities than the copper-base tubing previously used. This increase in velocity and pressure was made possible by the greater strength and corrosion resistance of stainless tubing.

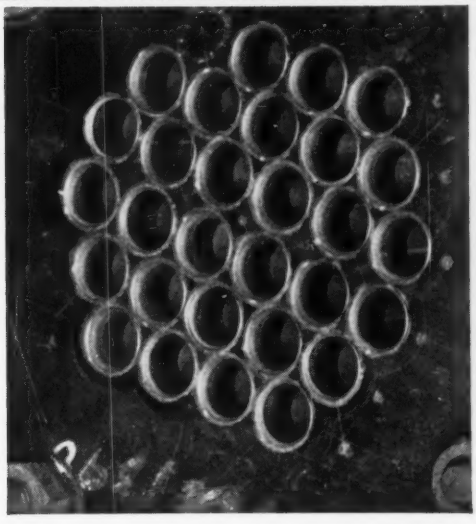
Carpenter stainless provides longer life between re-tubing because it serves better in any highly acidic water, and provides excellent heat transfer rates at high velocities and water temperatures. Carpenter tubing fully conforms to ASTM specifications for condensers and heat exchanger tubing.

Consult with your Carpenter representative on putting the cost-saving advantages of stainless into your condensers and heat exchangers. *The Application of Lightwall Stainless Tubing for Main Surface Condensers*, data collected from the above tests, and the *Selecting and Buying Guide TD120* are now available from Carpenter's "House of Corrosion Control." Contact your nearest office or write directly to The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

PRESSURE-TIGHT PROOF!

Tests conducted on ⅜" O.D. x .028" wall (22 BWG) Type 304 tubing in model condenser showed the following results:

1. In a hydrostatic test, 100-lb. psig water pressure was applied to the shell side of the condenser for a period of 24 hours . . . No leaks developed.
2. A film of soapy water was put on each tube sheet and 30-lb. psig air pressure put into the shell . . . No leaks developed.
3. Hydrostatic pressure applied again to the shell in increasing amounts up to 500-lb. psig . . . No leaks developed.



master key to savings in power plants

Carpenter

stainless tubing and pipe

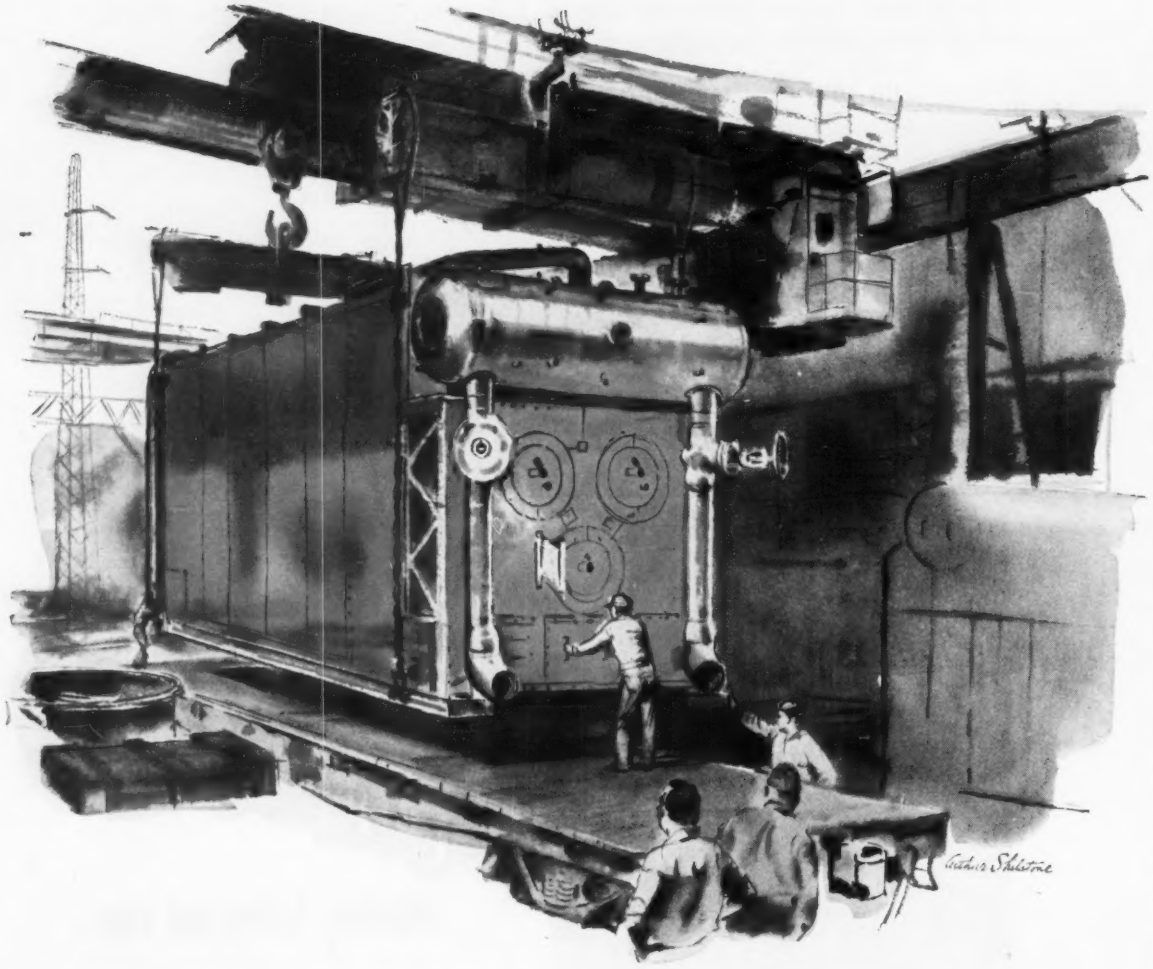
For more facts circle 229 on Reader Service card, p 125

RECORD-BREAKING HIGH

. . . wrapped in a Package

Shown below is the world's highest-pressure "package" boiler — a C-E Controlled Circulation Unit — Type PCC. It is designed to produce steam at a pressure of 1800 psi and 1050 F. Now installed at the General Electric Company plant at Fitchburg, Massachusetts, it provides steam for special testing purposes.

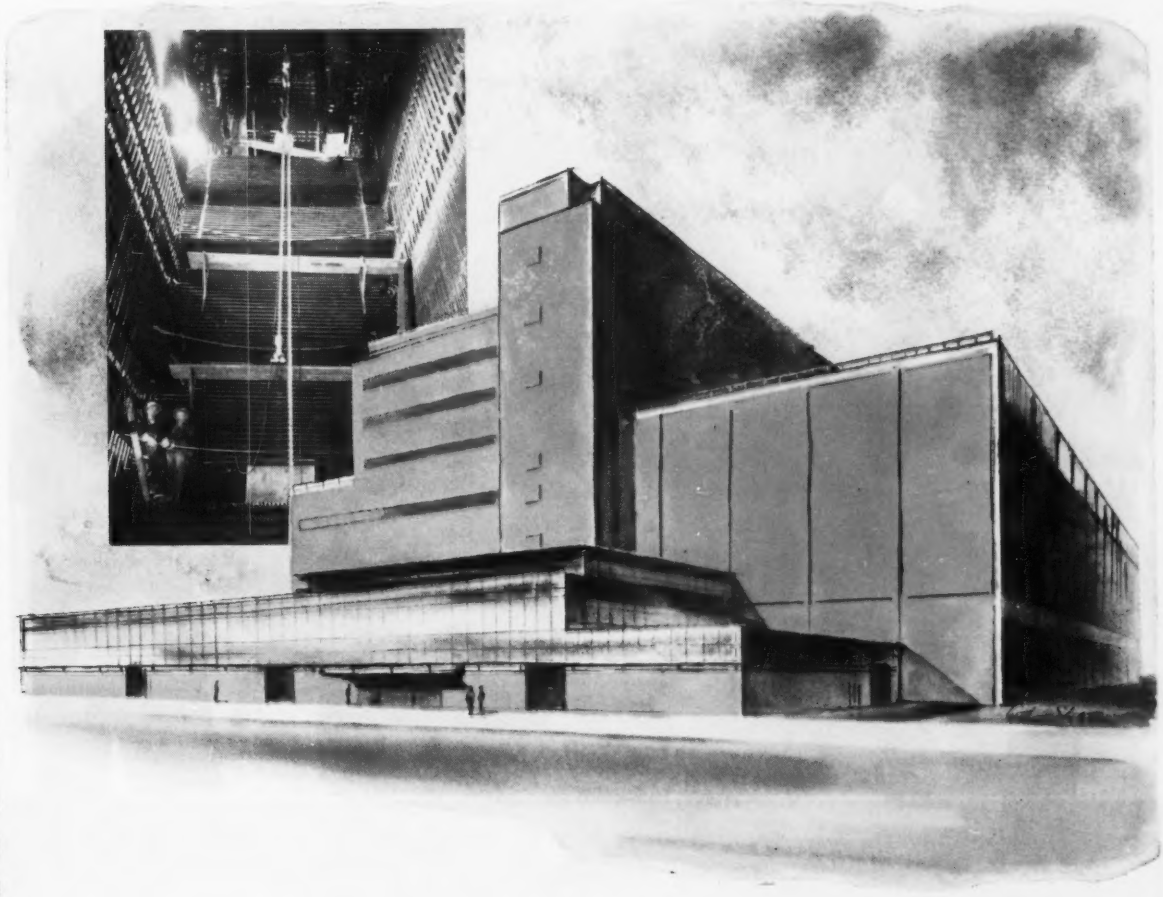
The plant on the facing page is the Eddystone Station of the Philadelphia Electric Company. It contains a C-E Sulzer Monotube Steam Generator, a small portion of which is shown in the upper left corner of the drawing. Later this year, when this boiler is placed in service, it will produce steam at the highest pressure and temperature ever used in commercial power practice — 5000 lb per sq in and 1200 F.



ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; NUCLEAR REACTORS

PRESSURE BOILERS by C-E

. . . or filling a Plant



The facts on the opposite page are of significance to you. They are part of the long list of C-E "firsts"—a list which includes the world's first boiler designed to produce as much as 3,850,000 lb steam per hour—and the world's largest package boiler, which produces 120,000 lb steam per hour. They give further evidence that—even in the biggest sizes and in the highest pressure ranges—C-E offers the most advanced designs for all steam requirements and with all fuels. To date, 38 C-E units have been purchased to provide 2400-pound pressure steam—or above—at the throttles of turbine-generators that have an aggregate capacity of about 8-million kilowatts. Fourteen of these units are already in service—one for a period of over three years.

When you are in the market for high-pressure boilers, it will pay you to contact the organization which offers you the broadest experience in the field—Combustion Engineering. In addition to these high pressure units, C-E also offers boilers in all types and sizes with capacities ranging from 4000 pounds of steam per hour, up to the largest in the world. All are designed to meet your needs reliably, efficiently and economically.

COMBUSTION ENGINEERING

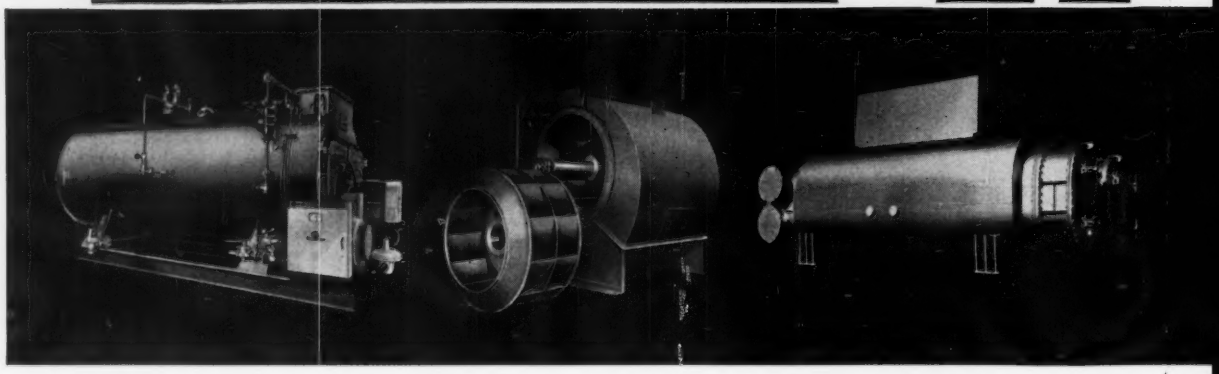
Combustion Engineering Building • 200 Madison Avenue, New York 16, N.Y.

C-219

PAPER MILL EQUIPMENT; PULVERIZERS; FLASH DRYING SYSTEMS; PRESSURE VESSELS; SOIL PIPE

For more facts circle 230 on Reader Service card, p 125

Evaluating equipment



Firebox, scotch-type, and package boilers for heat, steam, and industrial power.

Mechanical draft fans for induced and forced draft duty in power plants.

Balanced-flow surface condensers for condensing turbo-generator exhaust steam.

One call for all

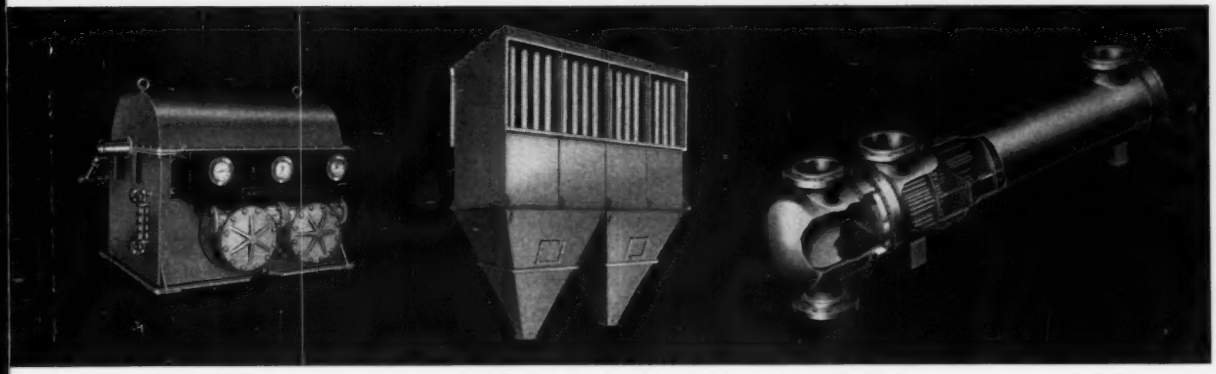
to increase over-all efficiency?

Be sure one of the sources you consider is

AMERICAN-Standard Industrial Division

HERE'S WHY: This one organization encompasses the six major fields of air conditioning, heating, ventilating, heat transfer, dust collection, and fluid drives . . . to offer one-source responsibility for quality and performance in equipment that is designed, engineered, and manufactured to work together.

By combining the engineering backgrounds and product lines of three American-Standard* divisions – American Blower, Ross Heat Exchanger, and Kewanee Boiler – the new Industrial Division brings many benefits to *all* business and industry. There are engineer-staffed offices in all principal cities to work with architects, consulting engineers, and contractors with equipment selection and on-the-job problems. Contact the one nearest you. American-Standard Industrial Division, Detroit 32, Michigan. In Canada: American-Standard Products (Canada) Limited, Toronto, Ontario.



Fluid drives for adjustable-speed control of feed-pump flow and fan volume.

Dust collectors and precipitators for recovering fly ash, eliminating dust.

Standard and engineered heat exchangers and feedwater heaters for every duty.

*AMERICAN-Standard and Standard® are trademarks of American Radiator & Standard Sanitary Corporation.

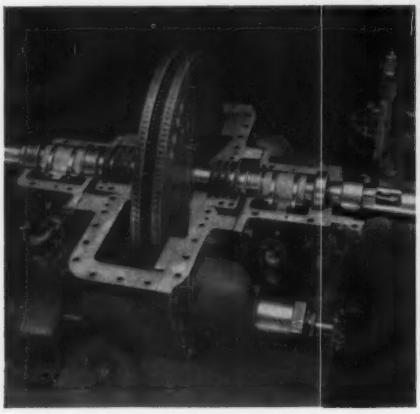
AMERICAN-Standard
INDUSTRIAL DIVISION

AMERICAN BLOWER PRODUCTS • ROSS PRODUCTS • KEWANEE PRODUCTS

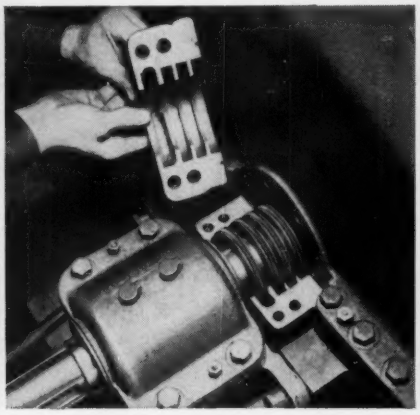
For more facts circle 231 on Reader Service card, p 125

Economical in operation... Dependable always

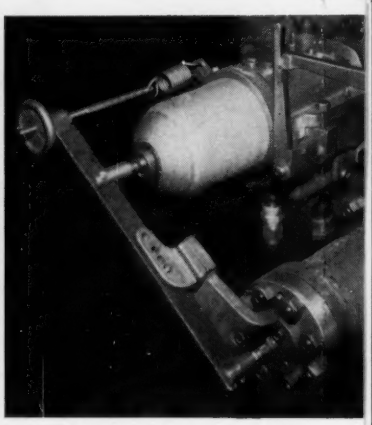
ELLIOTT



Precise alignment of shaft, through true centerline support, permits smooth and dependable operation at all operating temperatures. The entire rotor assembly is dynamically balanced.



Accessible shaft-seals simplify maintenance and routine inspection. Shaft surface under packing glands is stainless steel. Covers are readily removable without disturbing the upper-half casing.



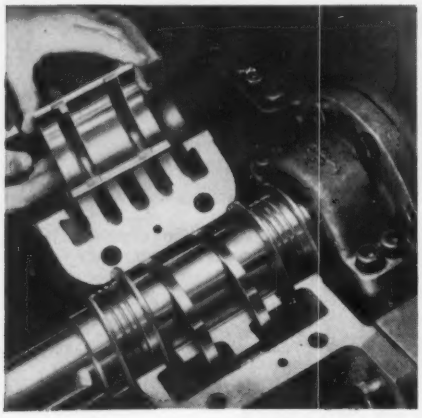
Simple, Positive direct-acting speed-governing system is dependable, weather-proof, accurate. Separate trip gives positive overspeed protection, and it may be easily reset against line pressure.

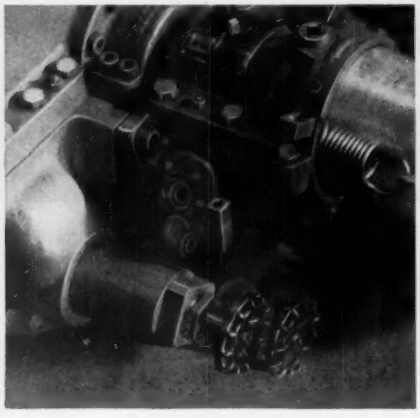
Only ELLIOTT Turbines give you all these PLUS features

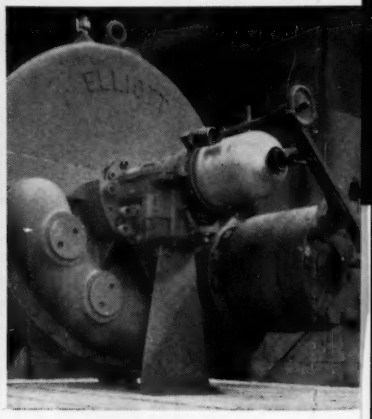
By separating the pedestal-mounted exhaust-end bearing from the hot turbine casing, the temperature distortion is minimized, and the vertical shaft movement is thereby eliminated.

Steam-saving hand valve with pilot, which can be opened against full steam pressure, reduces steam consumption at partial loads. This feature is available on all sizes of Elliott YR steam turbines.

All-weather protection is standard for Elliott YR turbines. They shrug off heat, dirt, snow, moisture or contaminated atmosphere. Stainless steel exposed parts are furnished for extreme conditions.

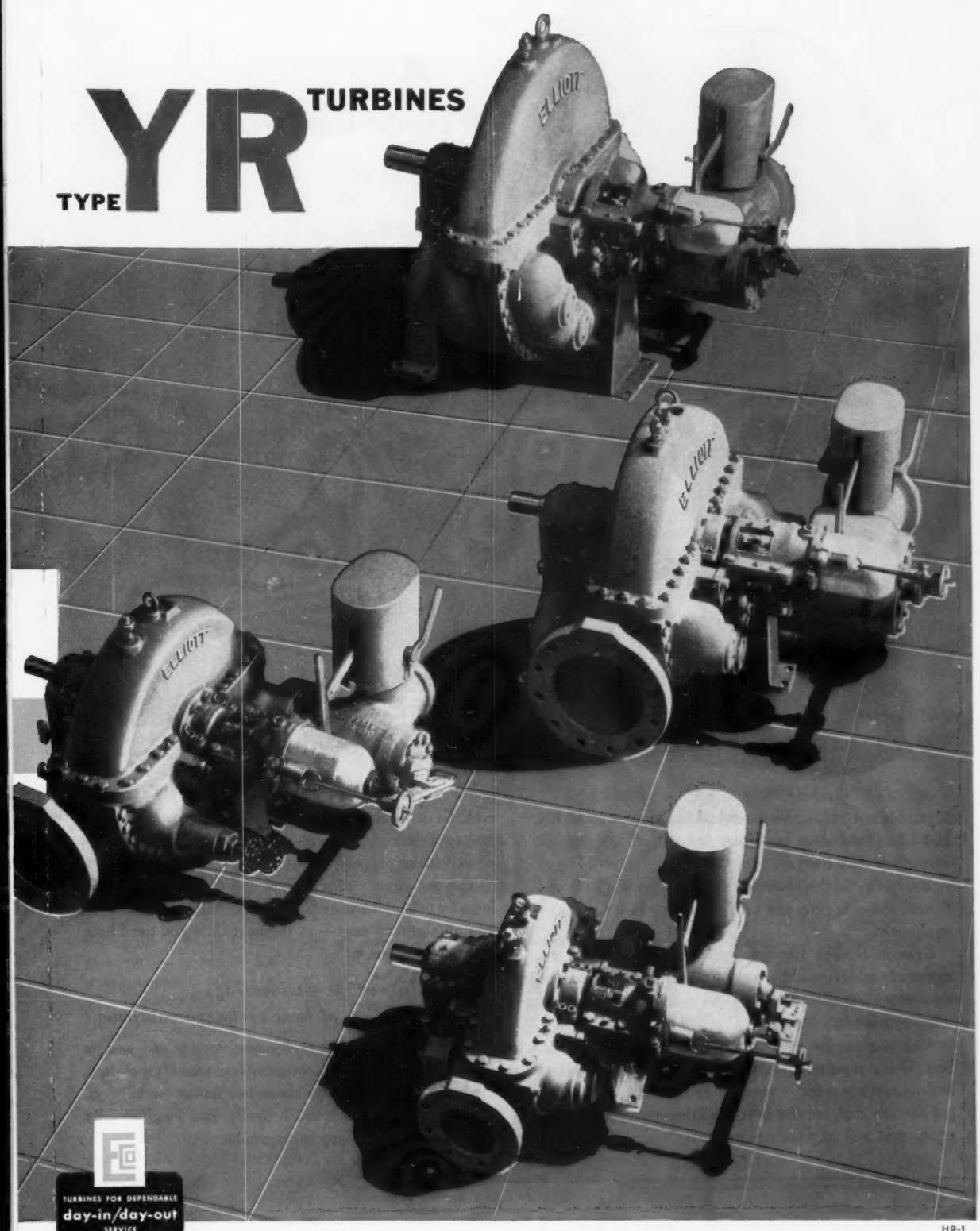






In addition to the units illustrated here, Elliott makes single-stage turbines in special frames, reduction gears, multistage mechanical drive turbines to 50,000 hp, and turbine-generators ranging through 44 mw.

TYPE **YR** TURBINES

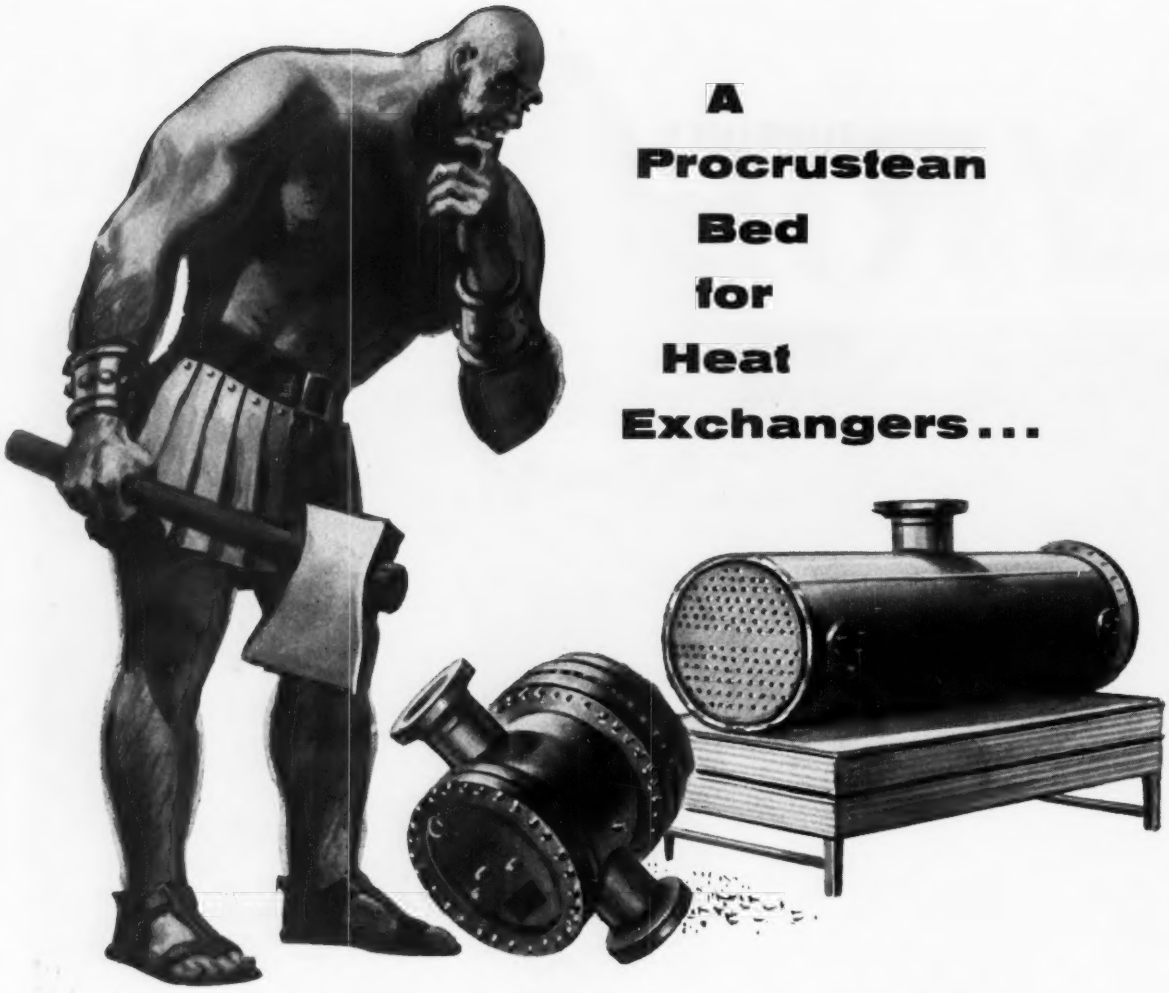


TURBINES FOR DEPENDABLE
day-in/day-out
SERVICE

H9-1

ELLIOTT Company JEANNETTE, PENNA.

For more facts circle 232 on Reader Service card, p 125



A Procrustean Bed for Heat Exchangers...

Mythological Procrustes stretched his victims to fit his bed when they were too short and cut off the surplus when they were too tall.

You can avoid this necessity by checking with Griscom-Russell the next time you are looking for heat exchange equipment.

Griscom-Russell has for over 90 years offered an extremely wide line of bare and finned tube heat transfer equipment for all industries — we can give you exactly what you need.

And you can be assured that G-R equipment is the best. G-R's reputation as one of the most engineering and research-minded companies in the field means you get designs that are the best available—or that special equipment will fit your needs exactly and at the lowest cost. Griscom-Russell's large plant, modern equipment and experienced working force mean that your equipment will be properly constructed.

You can stretch your dollars and shorten your problems by talking to your G-R representative. Let him tell you all about us now — or the next time you need heat exchange equipment.

Specialists in the engineering and construction of heat exchange equipment

air, gas and liquid heat exchangers, coolers and heaters —finned and bare tube, evaporators, steam generators, condensers, tank heaters, air-cooled fin-fan exchangers, sea water distilling plants, helically and longitudinally finned tubing, and many other products.

Griscom-Russell | A GENERAL PRECISION COMPANY

THE GRISCOM-RUSSELL COMPANY
MASSILLON, OHIO
A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

GR 397

For more facts circle 233 on Reader Service card, p 125

. . . to control water level at Long Sault Dam, St. Lawrence Power Project

MURCO GATE HOISTS

For the second largest hydroelectric power plant in the United States at Massena, New York -- as part of the St. Lawrence power project -- Uhl, Hall & Rich, project engineers, selected MURCO Gate Hoists to control the water level at Long Sault Dam.

MURCO Gate Hoists are designed from knowledge and experience . . . backed by over 75 years in design and manufacture . . . with hundreds of successful installations made for leading engineers, power companies, industrial plants, government power projects . . . each MURCO Gate Hoist designed to do its job, incorporated into its design the factors that meet the requirements of the operators.

MURCO Gate Hoists are designed and made for any size power dam . . . capacities from less than 1 ton to over 100 tons . . . from the smallest hand operated to the largest motor operated gate hoist, all made to specifications.

Courtesy of Union Carbide Plastics Company, Division of Union Carbide Corporation.

Illustrated is one of the eighteen MURCO Gate Hoists on the Long Sault Dam shown above. Each hoist weighs 93,000 lbs. and when shipped to the project was completely equipped with all electric motors, controls, limit switches, wired ready for operation when installed.

Each MURCO Gate Hoist, as illustrated, has 175 tons lifting capacity . . . will raise and lower the gates in the dam at a speed of 1 foot per minute.

The overall length of each unit is 57 feet . . . 8½ feet wide and 12½ feet high.

Write for complete information . . . Engineering Department recommendations . . . when you are planning power dam projects.

Manufacturers Since 1883

MURCO

D. J. MURRAY MANUFACTURING CO.

WAUSAU, WISCONSIN

For more facts circle 234 on Reader Service card, p 125

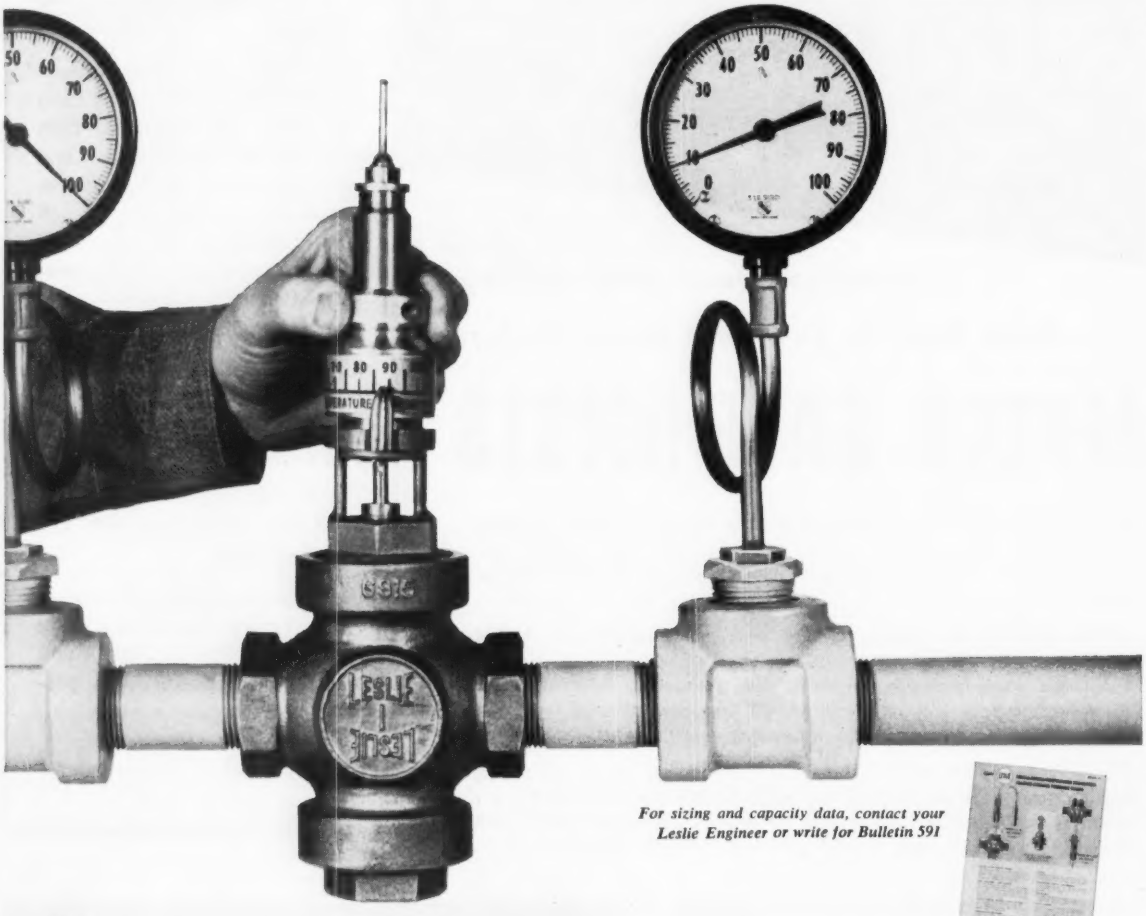
accuracy, reliability
ENGINEERED INTO LESLIE'S COMPLETE

NEW SINGLE-SEATED, BALANCED DISC, TEMPERATURE REGULATOR HANDLES INLET PRESSURES TO 100 psi.

New Leslie regulator can handle inlet pressure and pressure drops to 100 psi. High power, positive movement of an actuating bellows with solid liquid fill, and the virtually friction-less stuffing box provides stem movement exactly proportional to the temperature change at the bulb.

Designed for steam or water service, it features a single seated, self-aligning, tight closing inner valve. (Units can be changed in the field from direct to reverse acting, or from reverse to direct acting, simply by inverting body and main valve.)

Applications include instantaneous heaters or coolers—shell and tube or shell and coil heat exchangers; storage or tank heaters; and, process heaters or coolers of all types. Available in cast iron or cast bronze bodies for temperatures to 450°F. Sizes ¾ and 1", screwed connections.

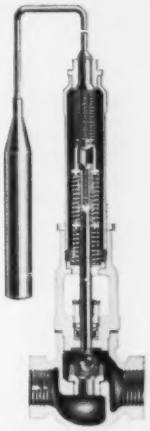


For sizing and capacity data, contact your Leslie Engineer or write for Bulletin 591

LC-10

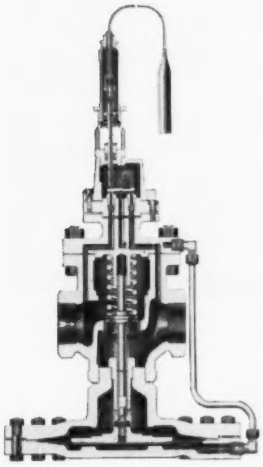
LINE OF TEMPERATURE REGULATORS.

OTHER VERSATILE LESLIE REGULATORS PROVIDE PRECISE TEMPERATURE AND PRESSURE CONTROL.



Bellows Operated Temperature Regulator For Small Flows

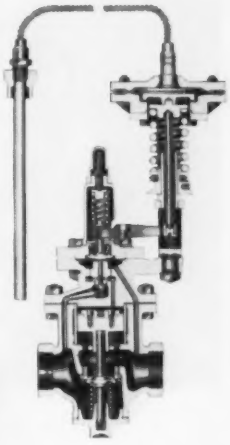
Direct Operated Design is used for small flow heating and cooling service, size ⅜, ½ and ¾". Liquid filled thermostatic element supplies ample power to stroke the single seated main valve. Valve travel is directly proportional to temperature change at bulb. This design is suitable for instantaneous and storage type heaters. It is also available in double seated construction for cooling service.



Class TKM Pilot Actuated, Metal Diaphragm Operated Temperature Regulator

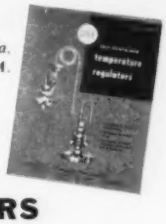
Pilot Operated, Single Element Control also uses the liquid filled element to operate pilot device which applies operating pressure from the regulator inlet to a diaphragm for stroking main valve in heating or cooling service. Large diaphragm area and operating pressure supply ample power for controlling long stroke, single seated main valve with full flow capacity in sizes ½-4". Regulator has a 3 to 5° throttling range and is suitable for all storage type heat exchangers and for any system requiring on-off control.

Class LTCO Pilot Actuated, Piston Operated Temperature Regulator



Pilot Operated, Duo-Matic (two-element control) design offers both temperature and pressure regulating functions in a pilot actuated, piston or diaphragm operated regulator. The valves can handle a range of inlet steam pressures in heating services from 25 to 600 psi and controlled pressure ranges of either 2 to 15 psi or 10 to 250 psi. These characteristics are ideal for all storage type heaters and most instantaneous heater problems. Available in sizes ¼-6" with iron, bronze and cast steel construction.

For complete sizing and capacity data, write for Bulletin 5307-A.



TRADE LESLIE MARK

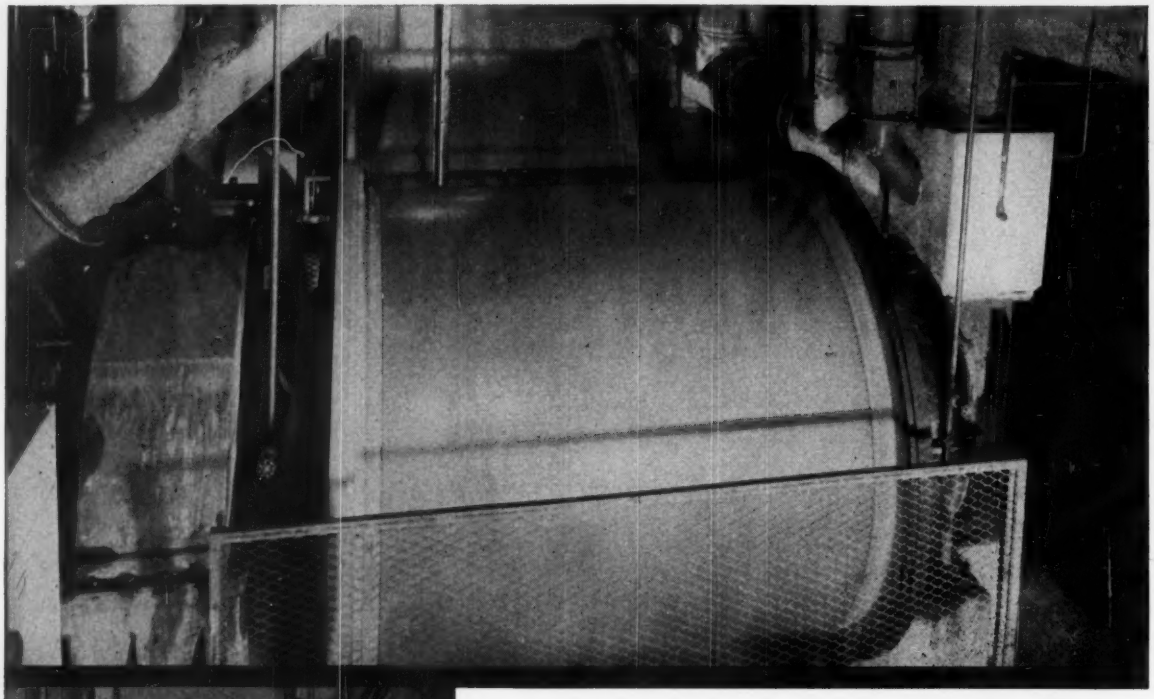
REGULATORS and CONTROLLERS

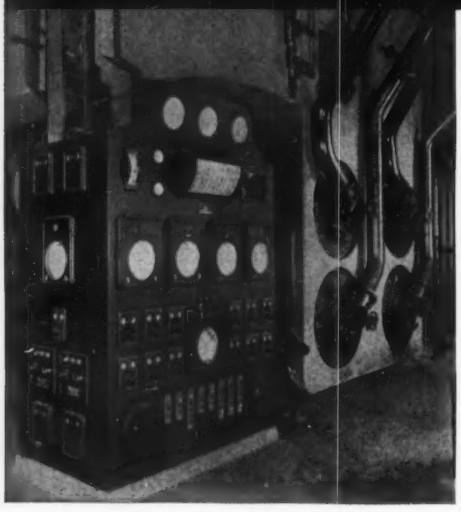
Leslie Co., 435-B Grant Ave., Lyndhurst, New Jersey

Over 275 Factory-Trained Engineers At Your Service—Nationwide!

For more facts circle 235 on Reader Service card, p 125

KENNEDY Pulverized Coal Firing System





. . . For Economy!

Shelby, Ohio—Municipal Light Department selects KENNEDY Pulverized Coal Firing System for 90,000 lb./hour steam plant generating 475 psig steam.

Shelby chose pulverized coal because of the availability of low cost coal, improved combustion efficiencies and lower stack losses, and because of its instant response to demand changes.

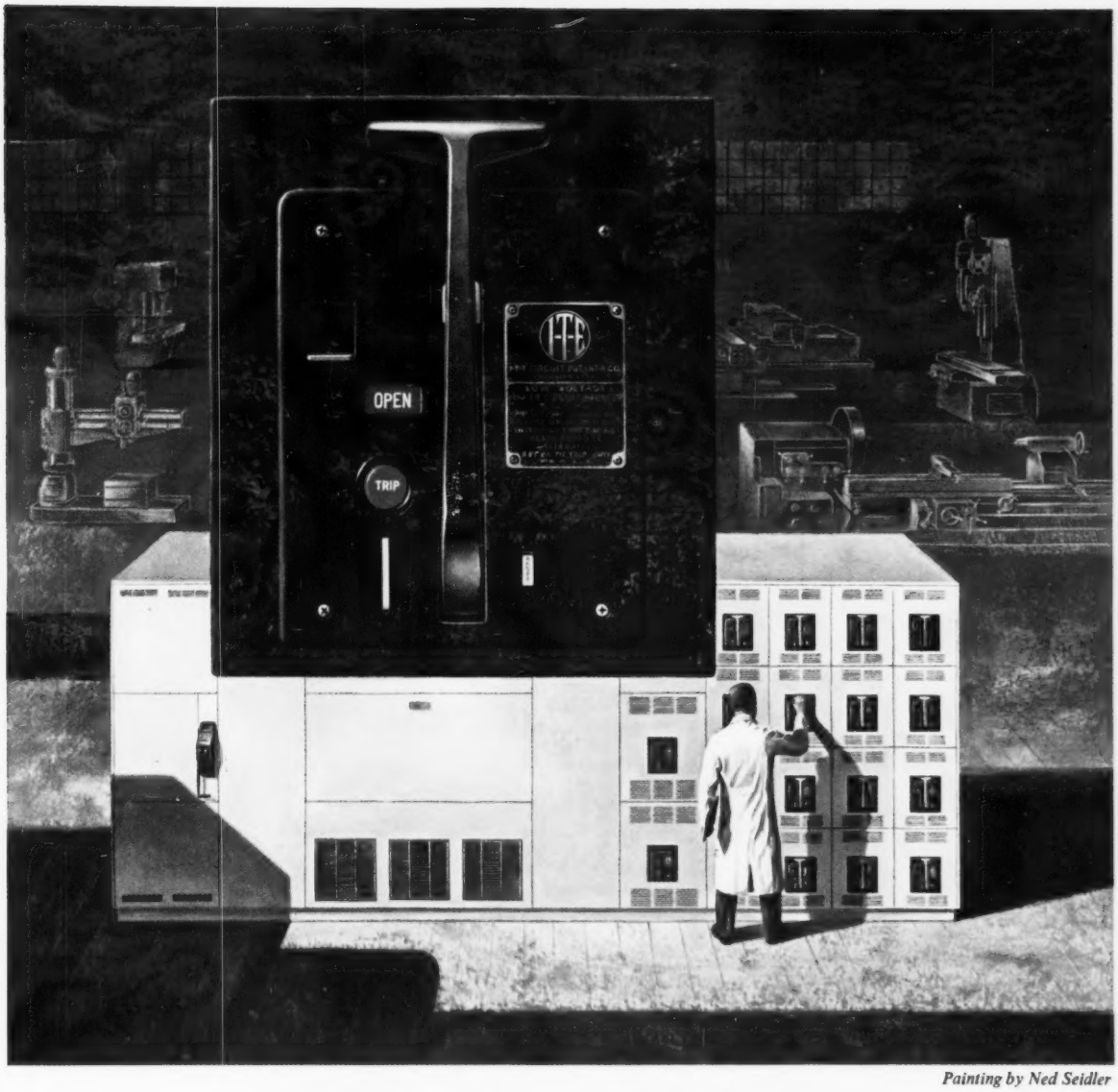
Shelby chose KENNEDY because no other pulverized coal firing system includes these desirable features:

- Fully air swept
- Coal pulverized to superfineness
- Coal completely carbureted, ready for combustion
- Big trunnions for air sweeping
- Balls added without shutting down
- Low operating and maintenance costs
- 85 to 90% through 200 mesh
- 20% moisture removed while pulverizing
- Pulverizes any coal—bituminous, anthracite or coke
- Tramp iron aids in pulverizing
- Reserves of fuel for fast response to demand

Consult KENNEDY before you specify your next firing system.

KENNEDY VAN SAUN
MANUFACTURING & ENGINEERING CORPORATION
405 PARK AVENUE, NEW YORK 22, N. Y. • FACTORY: DANVILLE, PA.

For more facts circle 236 on Reader Service card, p 125
Circle 237 on Reader Service card, p 125 ➤



Painting by Ned Seidler

FACT

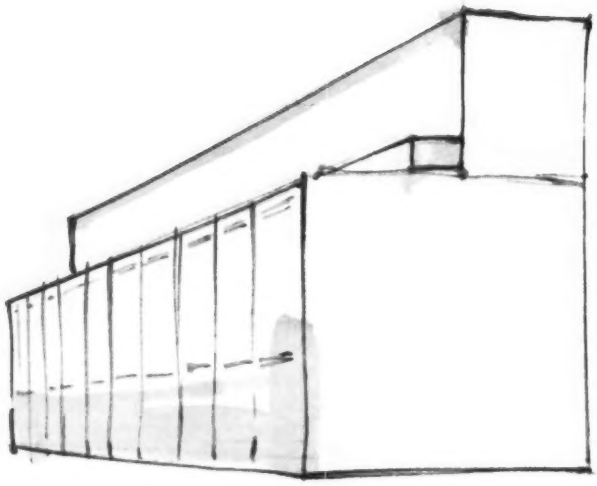
A dollar allocated for electrical equipment is worth more . . . when it is used to buy I-T-E equipment. Because I-T-E's policy is to build its equipment better, and yet charge no more.

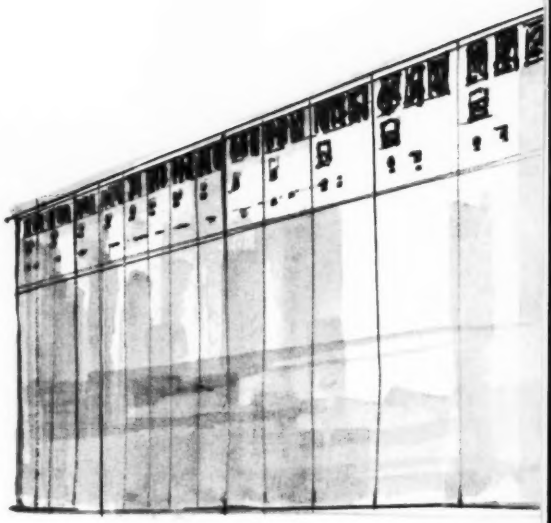
Take a typical secondary unit substation, for example. It features the new K-LINE circuit breakers . . . today's most advanced line. They stack four high in ratings up to 600 amp . . . save roughly ⅓ the space and half the weight formerly required. Circuit breaker pulldown handle with stored energy mechanism gives quick-make closure that means greater operator safety and longer contact life. The breaker can be drawn out to disconnect position without opening the door. And if the load increases later, expanded range trip devices adjust quickly and without added expense.

These features add up to real dollars and cents savings over the life of the equipment. Yet they cost nothing extra. In addition, I-T-E substations are engineered and manufactured in a single I-T-E plant for extra installation ease and better performance.

There are other I-T-E facts too. Turn page.

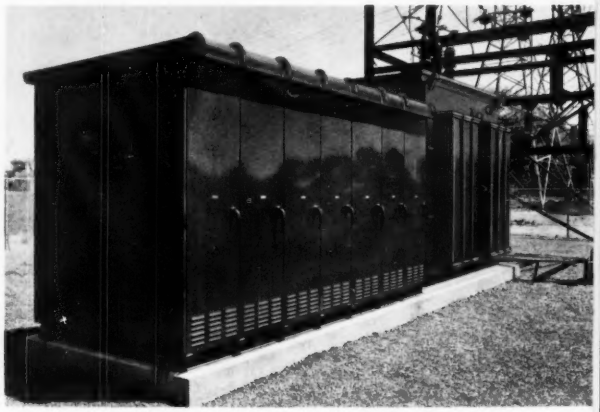
I-T-E CIRCUIT BREAKER COMPANY



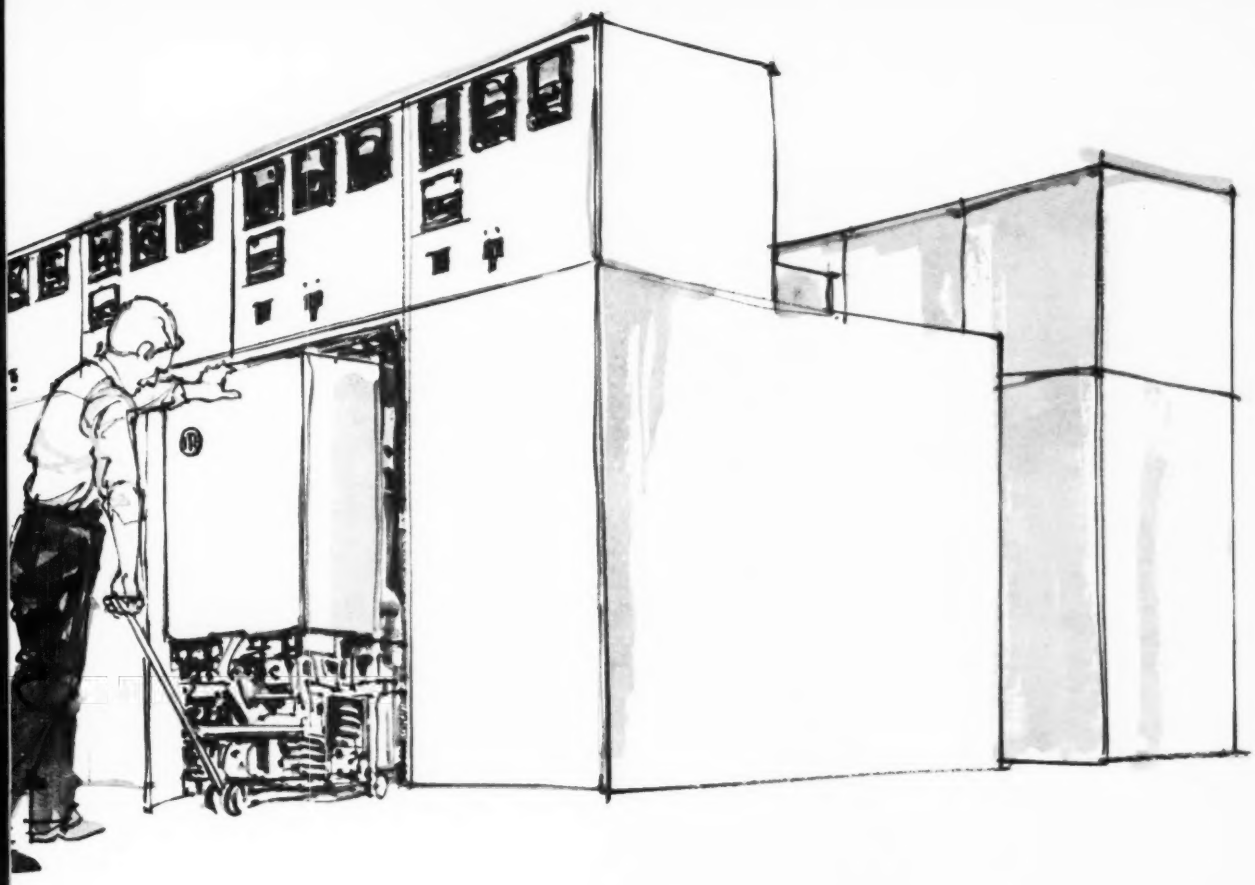


WHERE ELECTRICITY GOES I-T-E GOES

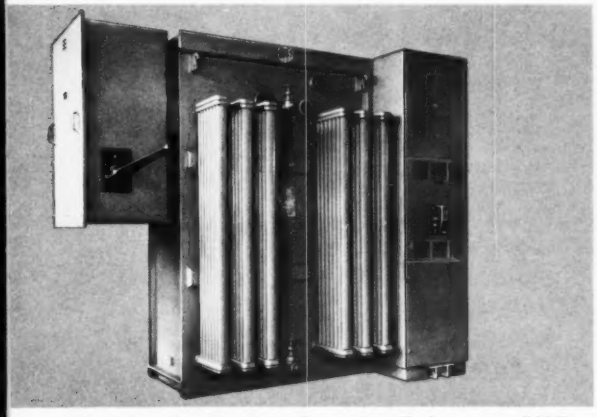
Are you fully acquainted with the broad I-T-E line . . . and the many ways it can help your dollars buy more?



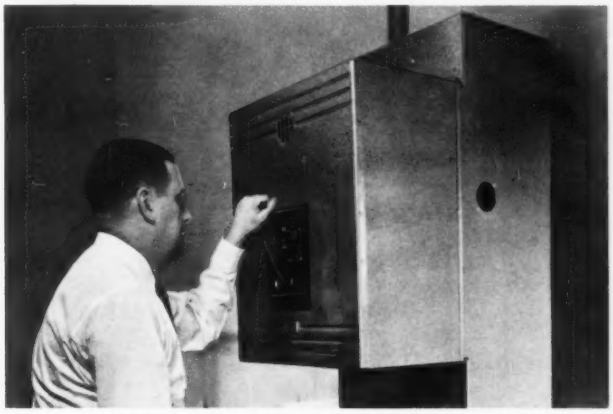
Custom designed at no extra cost. I-T-E primary unit substations are designed and built to meet the specified power, space and future expansion requirements of the particular installation for which they're ordered. In addition to standard outdoor metal-clad construction, weatherproof walk-in switchgear is also available. Transformer and switchgear sections are constructed in the same plant to assure smooth coordination of components, easier assembly, pretested performance, and on-time delivery.



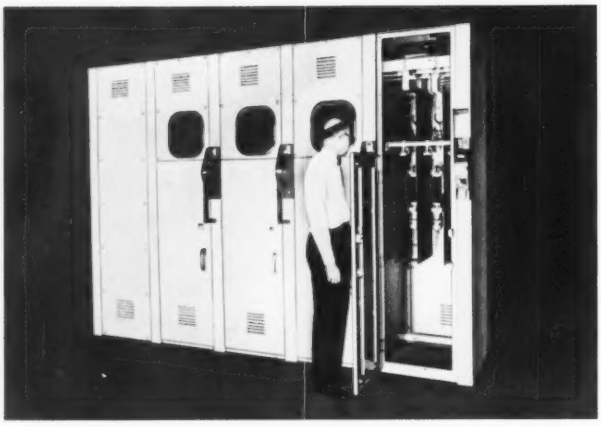
Protection for primary power. I-T-E metal-clad switchgear has many extra advantages not available elsewhere. Take a good close look. You'll find extra sturdiness that means extra serviceability. And extra craftsmanship that gives the owner a feeling of pride. For easy inspection, even the rear doors are hinged, and components are completely accessible. All essential circuit breaker components are mounted on the breaker for easier access. Uniform flux density magnetic arc field means superior protection . . . especially against high current faults. For extra safety, breakers stop automatically in test position when they're rolled into the compartments. They can't be moved into or out of connected position unless they're open.



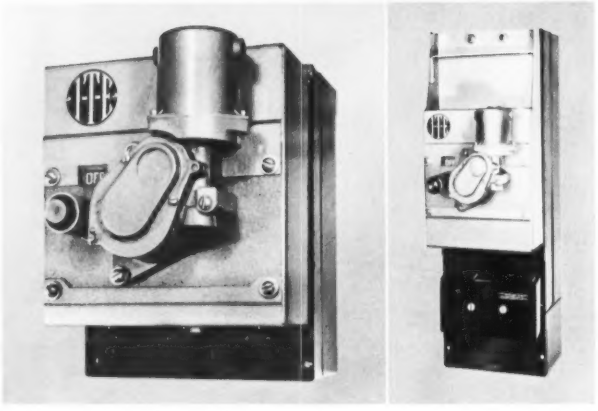
Self-contained substation. Saves installation cost. I-T-E TRANFO-UNIT combines primary disconnect, transformer and secondary circuit breakers all in one package. Nothing else to buy. Simplifies ordering. Delivered complete. Installation time and cost reduced to an absolute minimum. No complicated assembly of separate parts. Gives neat appearance. Completely safe. No live components open to contact by personnel. Needs no fence. Use for incoming power up to 3000 kva. Or spot near load areas in large plants.



600 volt value package. New URELITE® individually enclosed I-T-E K-LINE circuit breaker is ideal for single circuit protection and control, such as large motors and other heavy loads or for service entrance on many commercial-type buildings. Main disconnect contacts are visible through a side window for extra safety. Features quick-make closure, closed door disconnect, and expanded range trip device. Available in capacities from 15 to 1600 amp continuous, up to 75,000 amp interrupting.



Economical primary switching. I-T-E power switching centers save cost and time. Give dependable fused protection at low initial investment. Building block design speeds delivery. Preassembled units easy to install. Performance-proved I-T-E switches close safely into fault. Available for remote or automatic control. Up to 14.4 kv and 1200 amp.



Molded case economy . . . remote control luxury. Now I-T-E CORDON® circuit breakers are available with new TELEMAND* motor-operators for remote opening, closing or resetting. Gives pushbutton control from a distance. Permits automatic operation. CORDON circuit breakers provide up to 100,000 amp interrupting capacity in roughly half the switchboard space required by alternative devices. They cost approximately ⅓ less. TELEMAND is available for the complete range of molded case circuit breakers from 70 to 800 amp.

**Telemand is an I-T-E trademark*

I-T-E Circuit Breaker Company C-63A

1900 Hamilton St., Philadelphia 30, Pa.

- ☐ Secondary unit substations
- ☐ Metal-clad switchgear (4.16 and 13.8 kv)
- ☐ Primary unit substations
- ☐ URELITE circuit breakers
- ☐ Molded case circuit breakers
- ☐ Metal-enclosed bus
- ☐ Outdoor air switches
- ☐ TRANFO-UNITS
- ☐ Power switching centers
- ☐ TELEMAND (motor-operated molded circuit breakers)
- ☐ K-LINE LV switchgear (600 volt)
- ☐ Reclosers
- ☐ Distribution cutouts
- ☐ Other .....

Name ..... Title .....

Company .....

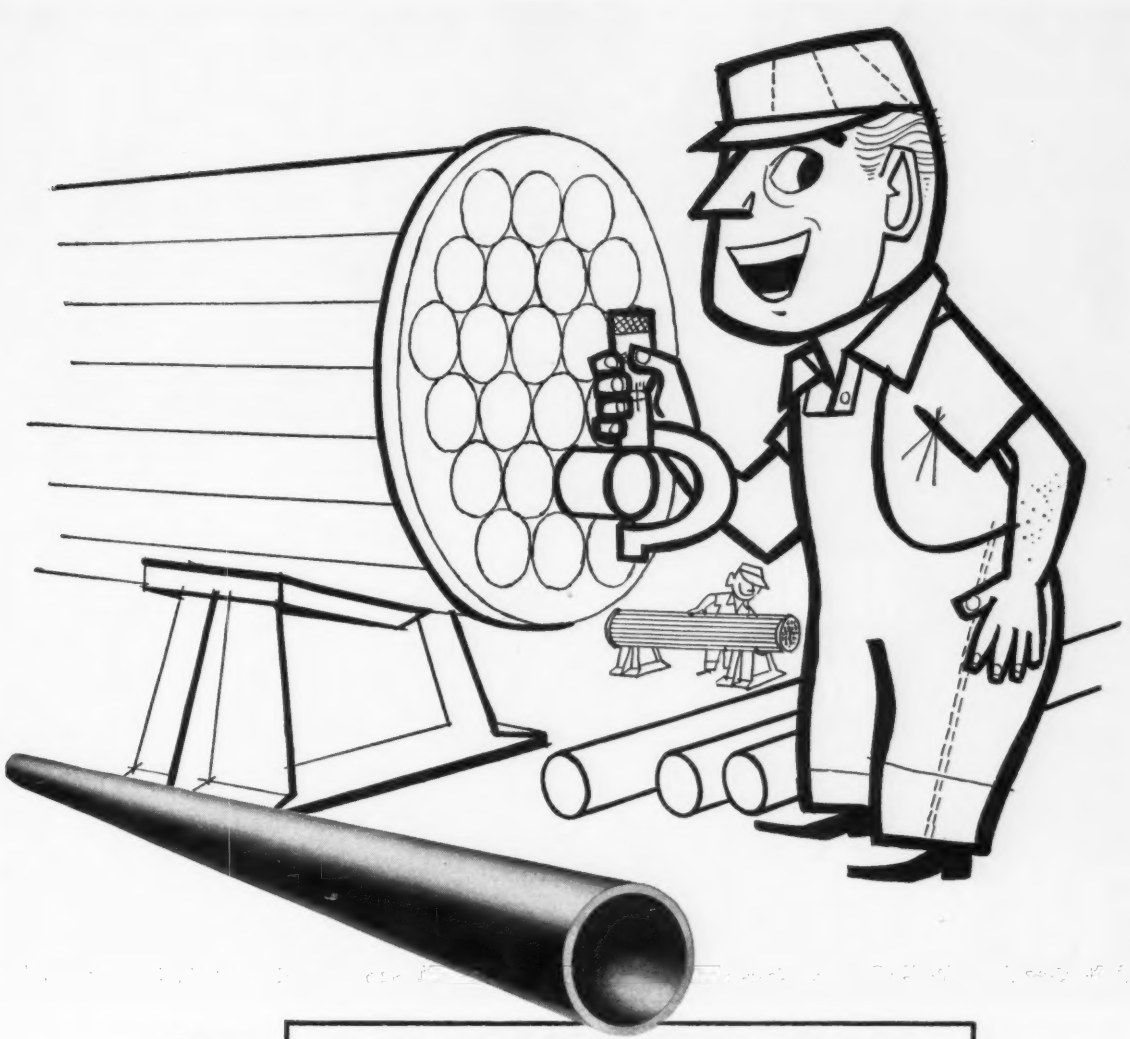
Street .....

City ..... Zone ..... State .....

SEND COUPON

Get complete, up-to-date information on I-T-E equipment.

I-T-E CIRCUIT BREAKER COMPANY



How B&W JOB-MATCHED TUBES meet Heat-Exchanger requirements

With B&W Job-Matched Heat-Exchanger Tubes you get:

- . . . tube tolerances and mechanical properties, controlled for ease of fabrication
- . . . a wide range of steels to meet any set of operating conditions
- . . . a complete range of tube sizes, for any type of heat exchanger

This means ease of fabrication to the heat-exchanger manufacturer — long service life to the heat-exchanger user—and ease of tube replacement to those concerned with maintenance.

For complete information about B&W Job-Matched Heat-Exchanger Tubes call the local B&W District Sales Office or write for Bulletin TB-329. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pennsylvania.

B&W

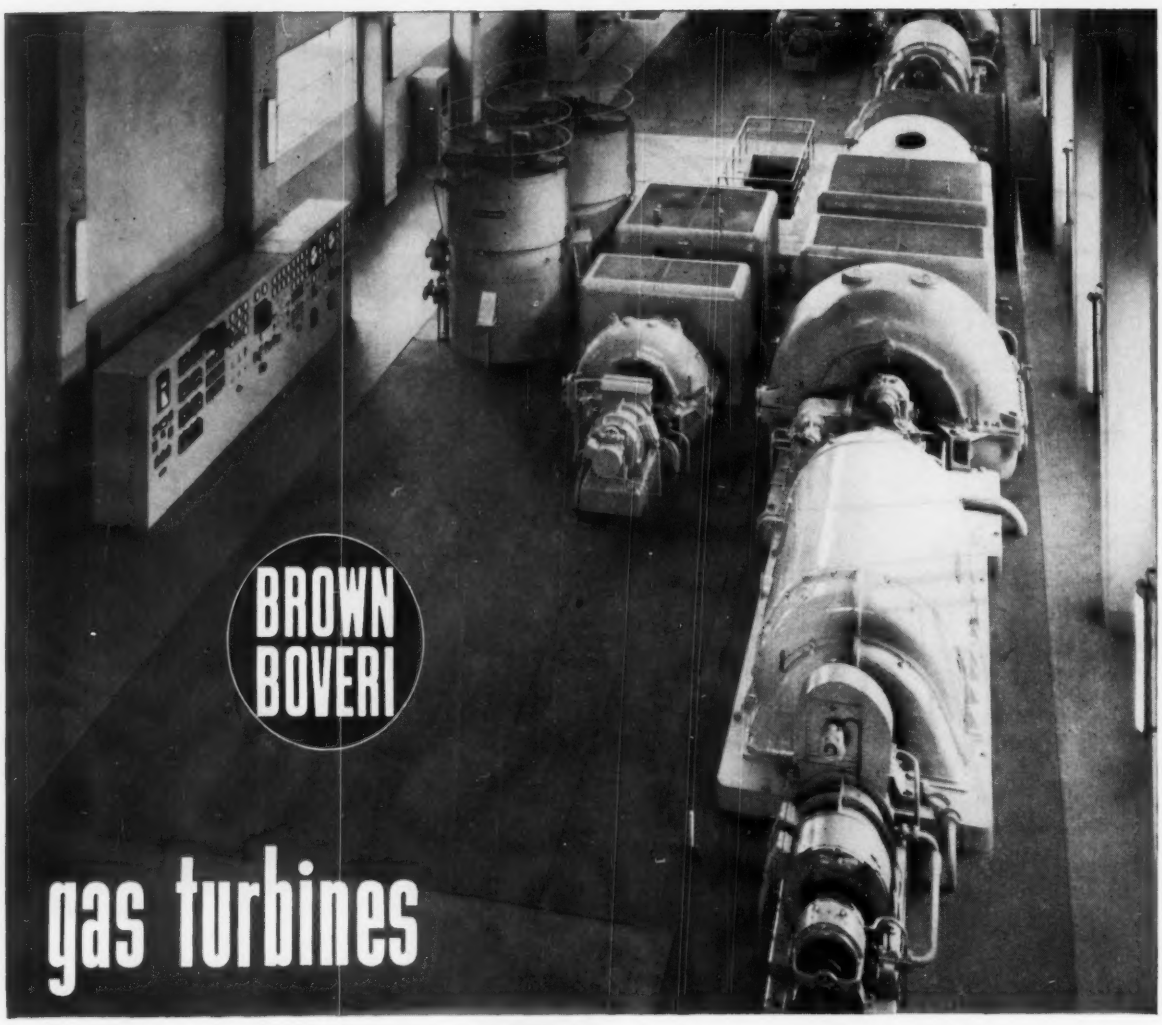
THE BABCOCK & WILCOX COMPANY

TUBULAR PRODUCTS DIVISION

TA-9002-SPI

Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals

For more facts circle 238 on Reader Service card, p 125



our 100th gas turbine now being built for MOORHEAD, MINN.

OVER 1,300,000 KW in total gas turbine capacity built or on order for industrial and utility applications, including 16 units in the United States, Puerto Rico and Canada with a maximum capacity of over 300,000 KW . . . *experience unmatched by any other manufacturer.*

PROVEN DEPENDABILITY AND ECONOMY of Brown Boveri gas turbines has been established in many years of operation in installations the world around, often under extremely adverse conditions.

STANDBY AND PEAKING POWER — The 7,400 KW Brown Boveri gas turbine (with a bonus wintertime capacity of up to 10,000 KW) purchased by the Moorhead municipal utility is tailormade for the city's peaking and standby requirements. Brown Boveri gas turbines offer many unique and proven advantages in this type of application.

POWER FACTOR CORRECTION using the generator as a synchronous condenser. A specially-developed coupling, exclusive with Brown Boveri, makes it possible to disconnect the generator from the turbine and reconnect it again at full speed whenever power generation is needed.

BASE LOAD OPERATION — Backed by a long record of engineering and production firsts, Brown Boveri gas turbines have been an unqualified success in many base load applications. And on the engineering horizon is the use of gas turbines in combination with steam cycles for even more efficient base load performance.

BROWN BOVERI CORPORATION

19 Rector Street, New York 6, N. Y.

Atlanta • Birmingham • Boston • Buffalo • Charlotte • Chicago • Cleveland • Dallas • Denver • Detroit • Hamilton, Ohio • Jacksonville
Kansas City • Knoxville • Miami • New Orleans • New York • Pasadena • Pittsburgh • Portland • Roanoke • San Francisco
San Juan • Syracuse • Tucson

For more facts circle 239 on Reader Service card, p 125

FULL-ROUNDED EDGES

You can get top-quality copper bus conductor from Chase in flat bar shape with full-rounded edges, as well as bar with rounded edge or rounded or square corners.

The full-rounded edge bars have no edges to cut through insulating wrapping and cause trouble on the job. And they can be made up readily in multiple-bar units to handle very heavy direct current loads, or for alternating current.

Chase® flat rectangular, *full-rounded* edge bus conductor is ideally-suited to use in making up bus duct.

Chase also makes many special type bus conductors, for specific applications. If you have particular requirements, why not talk them over with a Chase Engineer? Call the nearest Chase Warehouse or Sales Office, or write Chase at Waterbury 20, Connecticut.

Chase® **BRASS & COPPER CO.,** WATERBURY 20, CONN.
Subsidiary of ***Kennecott Copper Corporation***

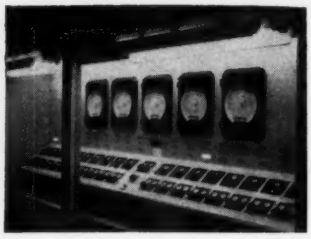
CHASE ELECTRICAL CONDUCTORS
are available in a variety of shapes
to suit every power-carrying need.

THE NATION'S HEADQUARTERS FOR **ALUMINUM • BRASS • BRONZE • COPPER • STAINLESS STEEL**
Atlanta Baltimore Boston Charlotte Chicago Cincinnati Cleveland Dallas Denver Detroit Grand Rapids Houston Indianapolis Kansas City, Mo. Los Angeles Milwaukee Minneapolis Newark New Orleans New York (Maspeth, L.I.) Philadelphia Pittsburgh Providence Rochester St. Louis San Francisco Seattle Waterbury

For more facts circle 240 on Reader Service card, p 125

(Advertisement)

HAGAN NEWSLETTER
Behind the Panel



CONTROLLED ATMOSPHERE FURNACE--WITH A CONTROLLED ATMOSPHERE

Very special high silicon steel sheets, to be used for transformer cores, are annealed in a furnace using hydrogen as a reducing atmosphere to remove occluded moisture and other impurities. A Hagan furnace pressure control system, specially designed for this application, has produced some interesting results. Tests have shown that, with Hagan's precision control, hydrogen flow can be reduced during certain times in the annealing cycle, with a consequent saving in hydrogen amounting to $12,000 annually, more than enough to pay for the controls the first year. But a much more important result is the general upgrading of product. In fact, recent checks have shown that quality of the product was improved by 200%. (Item G-1)

WASHDAY PROBLEM SOLVED . . . BY A HAGAN DUST COLLECTOR

A college high in the Rockies was so situated that flyash from the boiler showered the whole valley. This was particularly undesirable on washdays, since staff residences were clustered around the college and up and down the valley. The problem had an easy solution--since when a 54-tube Hagan Aerostatic Dust Collector was installed, the flyash menace to clean clothes simply ceased. In fact, one resident said--for the first time in many years, we had white snow this winter. Everyone is pleased, especially the college, since an electrostatic collector doing the same job would have cost 8 to 10 times as much as the Hagan unit. The principle of Selective Particle Acceleration, exclusive with Hagan, is the reason why Hagan dust collectors obtain remarkably high efficiencies, even with such finely divided dusts as fly ash. (Item G-2)

DUAL CONTROLS IMPROVE BLAST FURNACE EFFICIENCY

A modernization program for a blast furnace included the installation of a Hagan blast furnace blower control system. Designed to maintain a steady flow of blast air, the system has helped improve overall performance, and lower operating costs. Such results are to be expected from Hagan systems, but this particular installation differs from the average in one major aspect. The usual control panel is installed in the blower room, but an additional station is located in the cast house. This allows the cast house operator to take over direct control when desirable, and maintain the exact conditions required without the delay caused by signaling between cast house and blower room. This dual system has added much to the flexibility of the system and is credited with raising production. (Item G-3)

METERING CHEMICAL FEEDS?--THIS METER IS ACCURATE OVER WIDE TURNDOWN

At a large utility a Hagan Ring Balance meter was to be used to control the feed of lime and soda ash to their hot process lime softener. Because of extreme variations in flow, two line sizes were used in the meter run so that they could switch from a large to a small line when plant make-up requirements approached minimum rates. However, the small line proved to be inadequate. Rather than change lines, plant personnel decided to try operating over the full load range on the large line. The accuracy of the feed was checked by the plant chemist who would analyze the treated water to within 1 PPM. Chemicals used were also compared to the total volume of raw water. Both of these checks showed that the Hagan meter was holding the required chemical feed proportions within 1 PPM, even though loads frequently fell well below 10% of chart. (Item G-4)

HAGAN CHEMICALS & CONTROLS, INC.

Hagan Building, Room 705, Pittsburgh 30, Pennsylvania
In Canada: Hagan Corporation (Canada) Limited, Toronto
European Division: Via Flumendosa No. 13, Milano, Italy

If you would like more information on any of the above items, check the appropriate box below.

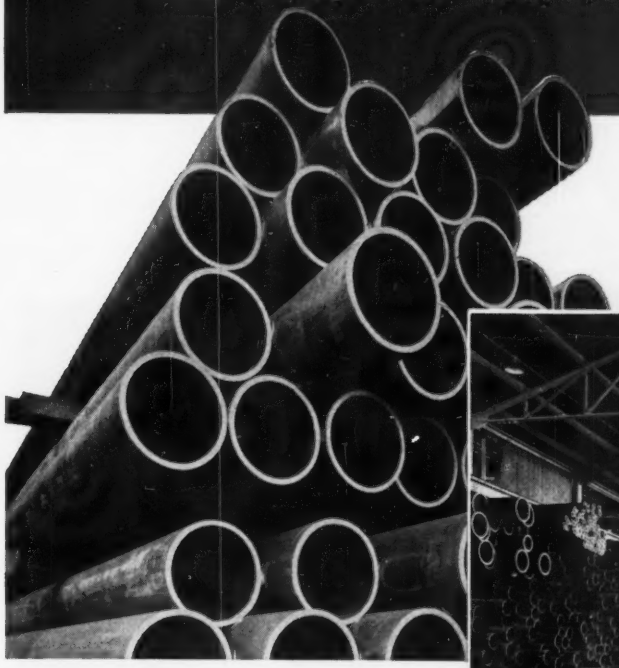
☐ Item G-1 ☐ Item G-2 ☐ Item G-3 ☐ Item G-4

401-1-66 HC-9-0262

For more facts circle 241 on Reader Service card, p 125

CHROME MOLY

1¼% - 2¼% - 5% .....



from Capitol

PIPE

WELD FITTINGS

FLANGES

FORGED FITTINGS

OTHER PIPING MATERIALS

WE CARRY LARGEST STOCK OF LOW AND INTERMEDIATE CHROME MOLY PIPE ½" THROUGH 20"; SEAMLESS WELDING FITTINGS 2" THROUGH 14" —AND FORGED ALLOY FITTINGS ¼" THROUGH 2".

A portion of the large and varied Pipe Stock that we carry for prompt shipments.

Our unusual familiarity with the "piping requirements" of Power Plants and Central Stations, as well as the Piping Fabricator and Contractor—all work to your advantage. On top of that, our inventory program allows you immediate shipments, rather than lengthy mill deliveries and over-runs. Of course, Capitol also assures you of the Highest Quality, Right Price, and Courteous Service.

CAPITOL PIPE

WORLD-WIDE

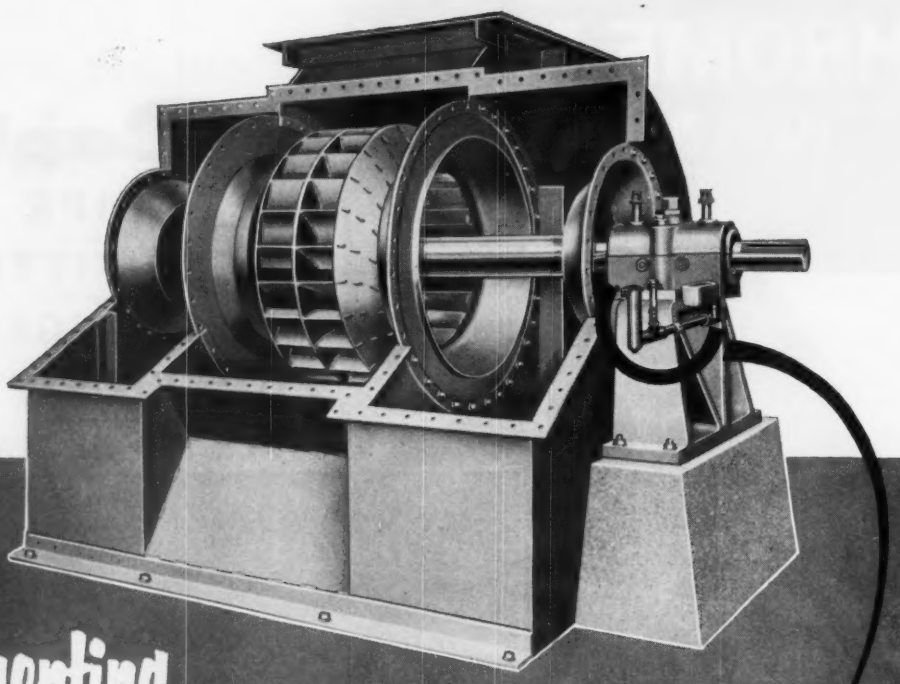
Capitol

PIPE & STEEL PRODUCTS, INC.

1275 SUBURBAN STATION BUILDING • 1617 PENNSYLVANIA BLVD.

RI. 6-5817 • PHILADELPHIA 3, PENNSYLVANIA

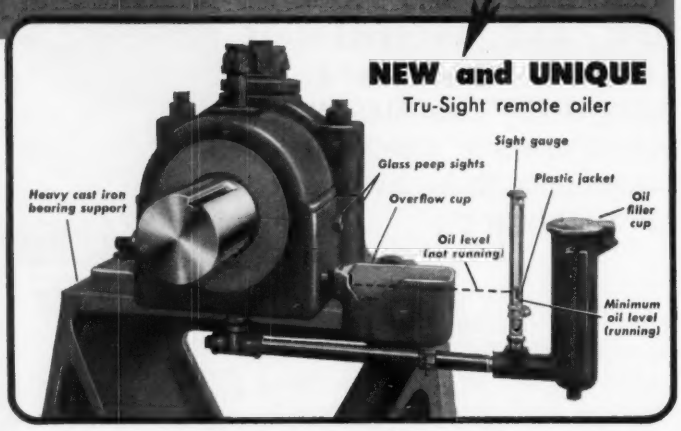
For more facts circle 242 on Reader Service card, p 125



Presenting... Another of the features distinguishing CLARAGE MECHANICAL DRAFT FANS

You get more than extra-heavy construction, extra-long service life from a Clarage Fan. You now get a vastly superior oiling arrangement for the bearings—as shown on the right.

Learn more about the many features that make Clarage Fans stand-out performers in forced and induced draft service. Write us today for catalogs or contact nearest Clarage sales engineering office. CLARAGE FAN COMPANY, Kalamazoo, Mich.



Designed to simplify maintenance, this Clarage Oiler provides for accurate remote oil level indication when fan is running or not running . . . simplified oil level adjustment . . . quick filling . . . automatic overflow to prevent overfilling . . . cleanliness due to improved shaft seal effectiveness and use of overflow cup.

CLARAGE ... dependable equipment for making air your servant

SALES ENGINEERING OFFICES IN ALL PRINCIPAL CITIES • IN CANADA: Canada Fans, Ltd., 4285 Richelieu St., Montreal

LOUIS N ROWLEY, EDITOR • JUNE 1959 • ESTABLISHED 1882 Power

New era in control

To even the most casual observer of power generation it must be clear that we are in the early stages of a great forward surge in the art of instrumentation and control. And the reasons are much the same as those that produced the last great era of advance—the advent of automatic combustion control after World War I.

Generating units are growing larger—the 500-mw unit is a reality and the 1000-mw unit isn't far away. We have taken the first steps beyond critical pressure and we're jumping tentatively across the ferrous-austenitic temperature divide. Manpower is increasingly expensive and we're more and more aware of areas where human control just can't do the job. Thus, for impelling reasons of safety and economy we must push the control art forward by a big notch.

Such a major advance requires the solution of several "hardware" problems. For example, we need temperature elements with faster dynamic response. In continuous analyzers for such functions as oxygen content, we need fast response *with* accuracy—not one at the expense of the other. And our problem with actuators is somewhat similar—how can we get the force and linear travel required by large units without penalties on response?

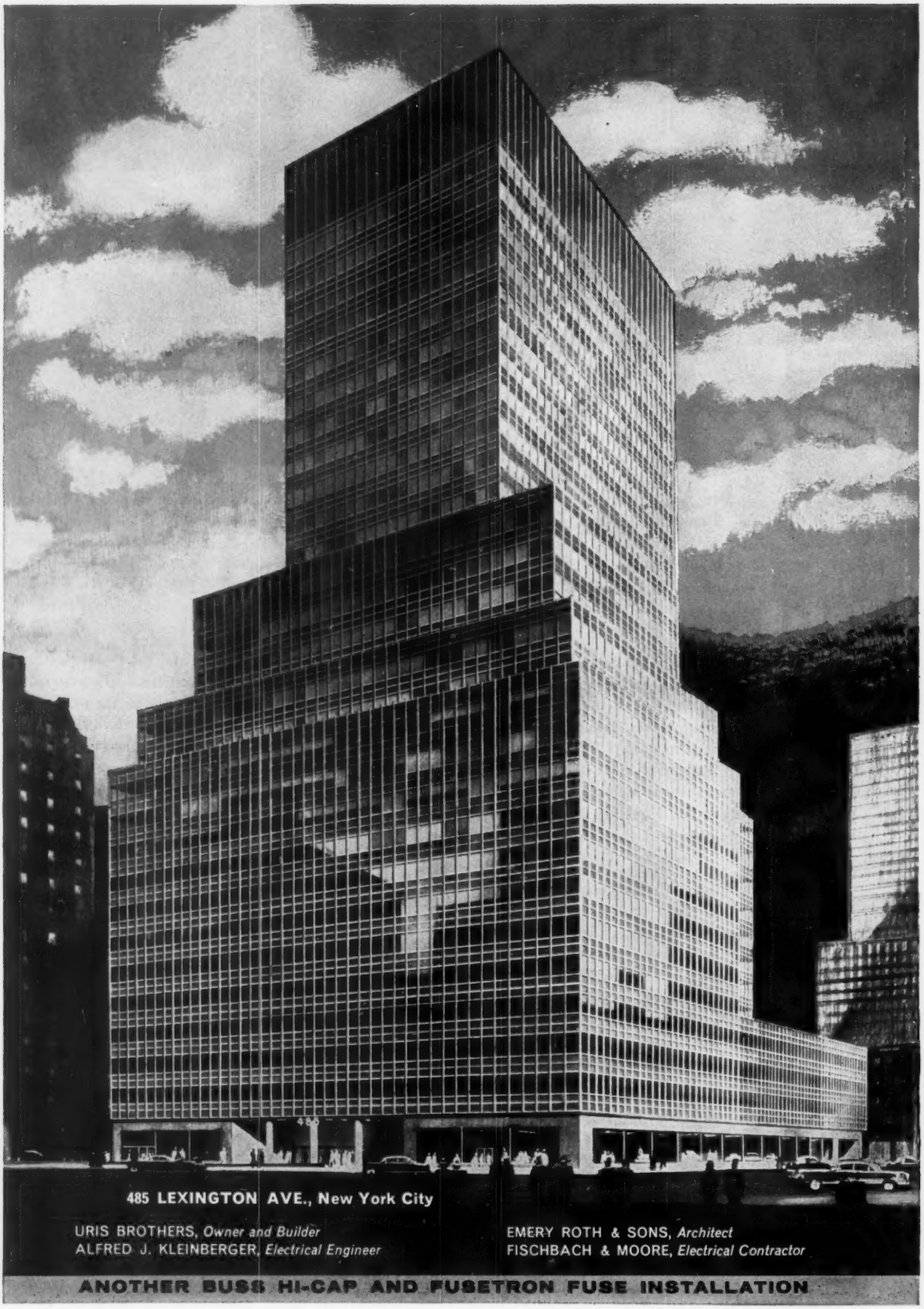
These and other specific "hardware" needs will take time and effort. But it seems to me that even greater time and effort must go into an entirely different kind of activity—what might be described as a massive job of digestion. Put another way, we face a tremendous task of exploring and appraising the manifold possibilities opened up by recent developments in electronics and solid-state physics.

We can now scan vast quantities of data in what seems like no time at all. We can record and print out these data with ease and speed. We can compute many possible alternatives quickly and select the best unerringly. In short, we have at our disposal what seems like a bottomless bag of tricks from the growing field of computer technology.

We are now designing at least two completely automatic steam-electric stations. (POWER, May 1959, pp 64, 65) and can visualize the outlines of completely automatic power systems. But much remains to be done before these pioneering ventures become commonplaces.

Faced with a greatly expanded variety of control means and a host of ideas for applying them, we must find time, I believe, for fresh and searching looks at just what we are trying to do. Exactly what do we need for guiding and controlling plant operation, for measuring and recording performance, for analyzing results to achieve peak efficiency and lowest cost? In other words, what are the *basic* functions involved in the area loosely labeled "instrumentation and control" and how can we accomplish them with a minimum of duplication and cost?

This implies the "systems" approach to power-plant control—a from-the-beginning integration of control-system design and total-system design aimed at yielding not only a better control system but equipment and plants that are easier to control. Such a searching analysis will yield control systems tightly geared to needs and of the highest order of effectiveness. And it should yield still another important dividend — control-system cost that is a reasonable proportion of the total plant cost.



485 LEXINGTON AVE., New York City

URIS BROTHERS, *Owner and Builder*
ALFRED J. KLEINBERGER, *Electrical Engineer*

EMERY ROTH & SONS, *Architect*
FISCHBACH & MOORE, *Electrical Contractor*

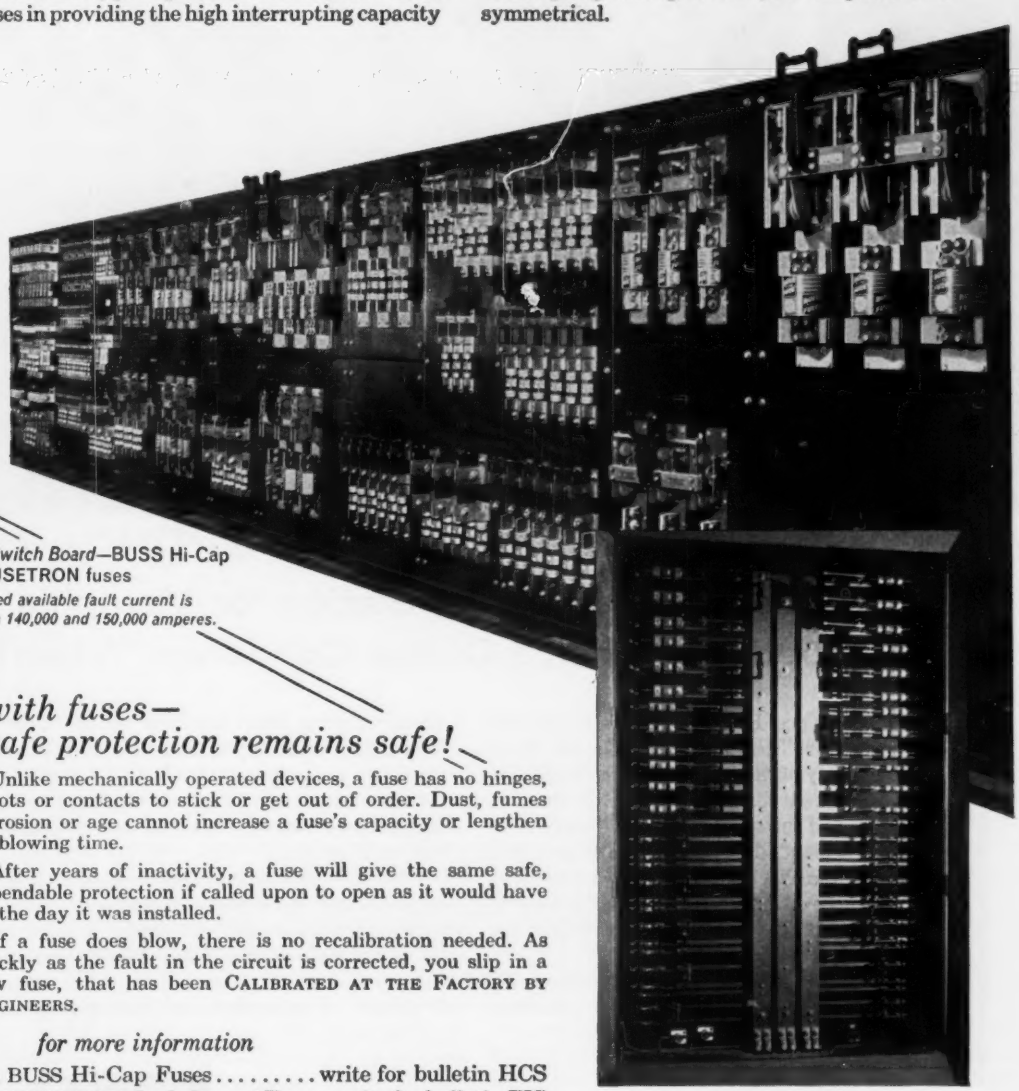
ANOTHER BUSS HI-CAP AND FUSETRON FUSE INSTALLATION

Electrical Protection goes MODERN *with* BUSS Fuses at 485 Lexington Ave., New York, N.Y.

In keeping with the modern trend the electrical protection for this new 30 story office building is BUSS Hi-Cap and FUSETRON dual-element fuses.

No other type of protective device can match fuses in providing the high interrupting capacity and dependability required for today's circuits.

BUSS Hi-Cap fuses have a NEMA interrupting rating of 200,000 amperes rms symmetrical. FUSETRON dual-element fuses have a NEMA interrupting rating of 100,000 amperes rms symmetrical.



Main Switch Board—BUSS Hi-Cap *and* FUSETRON fuses

Estimated available fault current is between 140,000 and 150,000 amperes.

with fuses— safe protection remains safe!

Unlike mechanically operated devices, a fuse has no hinges, pivots or contacts to stick or get out of order. Dust, fumes corrosion or age cannot increase a fuse's capacity or lengthen its blowing time.

After years of inactivity, a fuse will give the same safe, dependable protection if called upon to open as it would have on the day it was installed.

If a fuse does blow, there is no recalibration needed. As quickly as the fault in the circuit is corrected, you slip in a new fuse, that has been CALIBRATED AT THE FACTORY BY ENGINEERS.

for more information

On BUSS Hi-Cap Fuses..... write for bulletin HCS
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Distribution Panels
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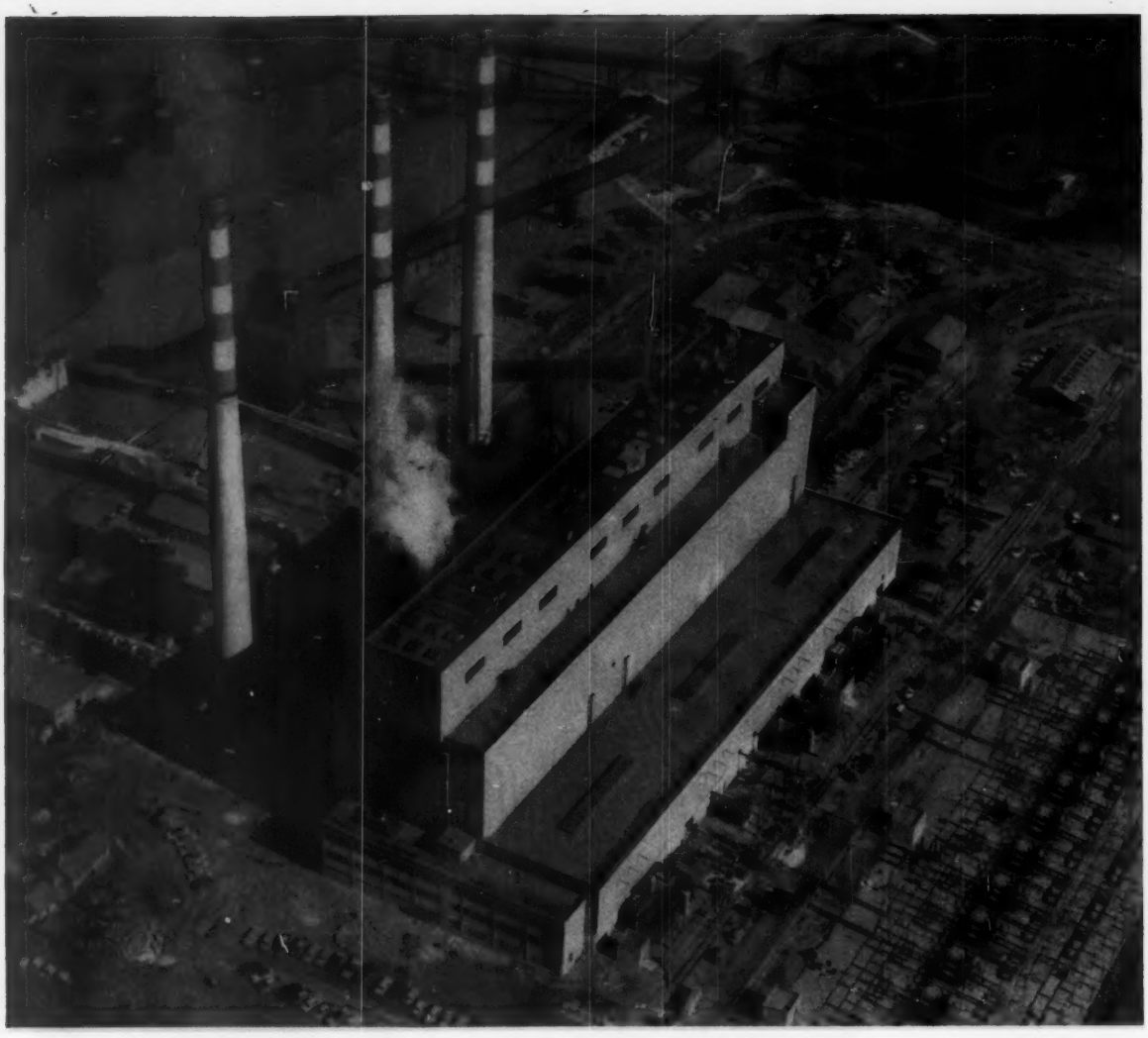
BUSSMANN MFG. DIV., McGRAW-EDISON CO., ST. LOUIS 7, MO.

For more facts circle 244 on Reader Service card, p 125



New Electric Generating Station for Memphis Equipped with Phelps Dodge Condenser Tubes!

The new Thos. H. Allen Electric Generating Station of the Memphis Light, Gas & Water Division, City of Memphis, Tenn., is designed to answer the need for increased electric power in Memphis and surrounding Shelby County. This mammoth plant, designed by Burns and Roe, Inc., and constructed under their supervision, has three hydrogen-cooled turbine generators and three multiple-pass condensers, with a new capability of 812,500 kilowatts.

Within the condensers are more than 298 miles of Phelps Dodge Admiralty condenser tubes, weighing about a million pounds. These 30-foot-long tubes help each unit condense steam from the generators at the rate of over one million pounds per hour. Each condenser has a heat transfer-rate of 980 BTU per pound of condensed steam.

Phelps Dodge condenser tubes are known for lasting quality and expert workmanship in industries using heat transfer equipment. This reputation has made Phelps Dodge a leading manufacturer of copper and copper-alloy tubes for the fabricators of condensers and heat exchangers.

PHELPS DODGE COPPER PRODUCTS
CORPORATION
300 Park Avenue, New York 22, N. Y.

PD

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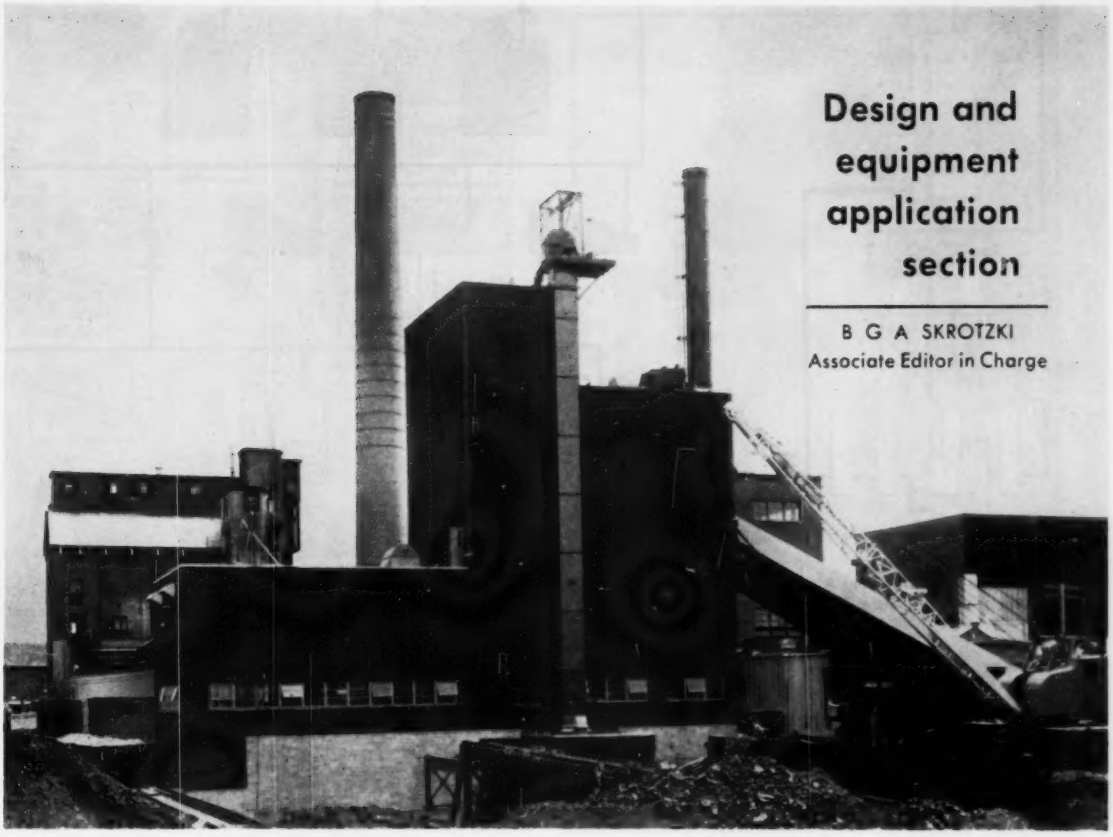


Design and equipment application section

B G A SKROTZKI
Associate Editor in Charge

St. Croix Paper Co's modernization, expansion with an eye to the future show . . .

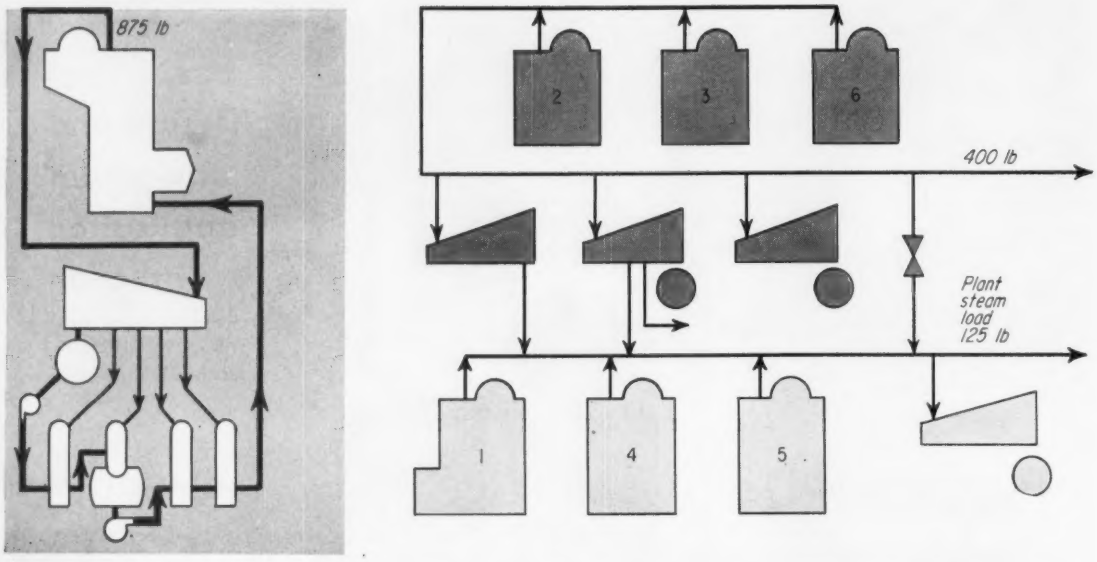
How long-range plans trim power costs

By P L NELSON, Associate, Chas T Main Inc

St. Croix Paper Company's plant at Woodland, Maine, boasts a 50-year record as one of the nation's lowest-operating-cost paper mills. Credit this to excellent original design, a good plant site and topnotch engineering by plant management. However, skyrocketing demand for newsprint had plant personnel expanding facilities almost faster than they could plan them. In 1953 a new boiler and turbine-generator went into operation, but by 1955 St. Croix's management decided to boost newsprint capacity 50%. At this point Charles T Main Inc got a call to run a complete study of mill requirements and come up with plans for present and future growth. How our expansion plans cut costs and why we planned them that way should interest you since the same techniques apply to many other power plants.

St. Croix power plant supplied all mill steam and electric requirements and carried the town load to boot. Power generation combined hydro and steam units, with hydro supplying a decreasing percentage as plant capacity soared. In addition, process steam load and electrical demand became increasingly unbalanced as heavy electric load of wood grinding, etc took its toll. Our problem: prepare plans for immediate modernization with the unbalance in mind and see that future changes result in an increasingly integrated and efficient plant.

Heat balances for expanded plant quickly proved boilers in existing steam power plant had sufficient capacity to carry added process steam load of a new paper machine as well as driving existing steam turbines. Electric load was a different story. Of the existing steam turbine-generators only three high-pressure machines could be counted as firm capacity. Steam capacity figures made no allowance for four boilers. Boiler No. 1 burned only wood refuse one shift a day with steam generation secondary. Boilers No. 4 and 5 were over 30 years old, with riveted drums. They faced condemnation



UNIT CYCLE isolated from old plant operates as a small central station with a new pressure level of 850 psig. Process load of 125- and 30-psig steam will continue. Future high-pressure extraction turbines will eventually eliminate 400-psig steam generation

or derating. Fourth unit, an old electric boiler, gave no help with electricity already short.

Hydro power consisted of three machines at Grand Falls Dam 12 miles upstream from Woodland, three machines at Woodland Hydro and four grinder drive helper motors arranged to generate power when not used for grinding. Total hydro power depended not only on generator capacity but also on available flow from St. Croix River. Maximum hydro was about 17,000 kw, but this was available only two months a year; average hydro power actually ran about 12,650 kw. We could not take this hydro figure as firm, but had to calculate rock-bottom power we could count on. Flow records showed us that enough water to produce 4500 kw was available 97% of the time, and dropped to the minimum only about once in ten years. We took this as our firm hydro-power figure.

Total capacity before expansion ran 22,500 kw compared to an average load of 20,000 kw. Added paper capacity would boost plant load to 33,000 kw, with peaks above this. To keep plant expansion reasonable our plans called for 13,500-kw extra capacity to operate at 100% load factor six days a week. This high load factor resulted from electrical load of new pulp and paper machinery.

Cycle planning to meet power requirements gave us our first big opportunity to trim operating costs. Since process-steam needs were filled, unit would be designed for a condensing cycle without process extraction. But we included regenerative feedwater heating for high cycle efficiency.

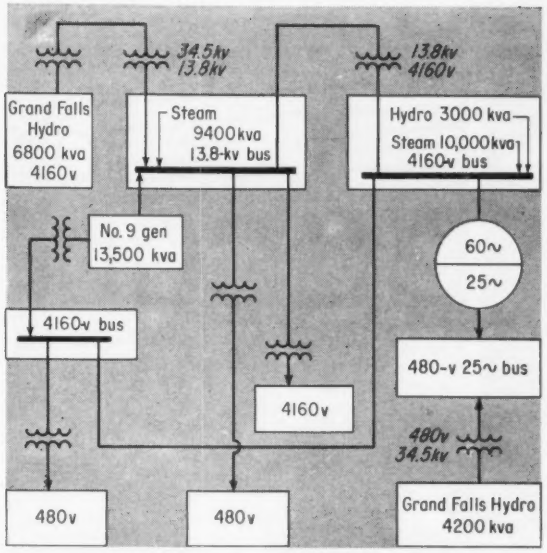
High load factor for this unit allowed us to design for 850-psig 900-F steam. Power plants of this capacity and type generally use 600-psig 825-F steam. Increased cycle efficiency with high temperature and pressure justified added expense of designing for these conditions when high plant load factor and fuel cost were considered.

Unit cycle design, resembling a small central station, seemed practical for our new boiler-turbine team because process-steam extraction did not enter the picture. Only deviation from unit system is a 400-psig emergency line from old high-pressure header, which allows operation of new turbine during outages of its boiler, or when loads are too small for practical boiler operation.

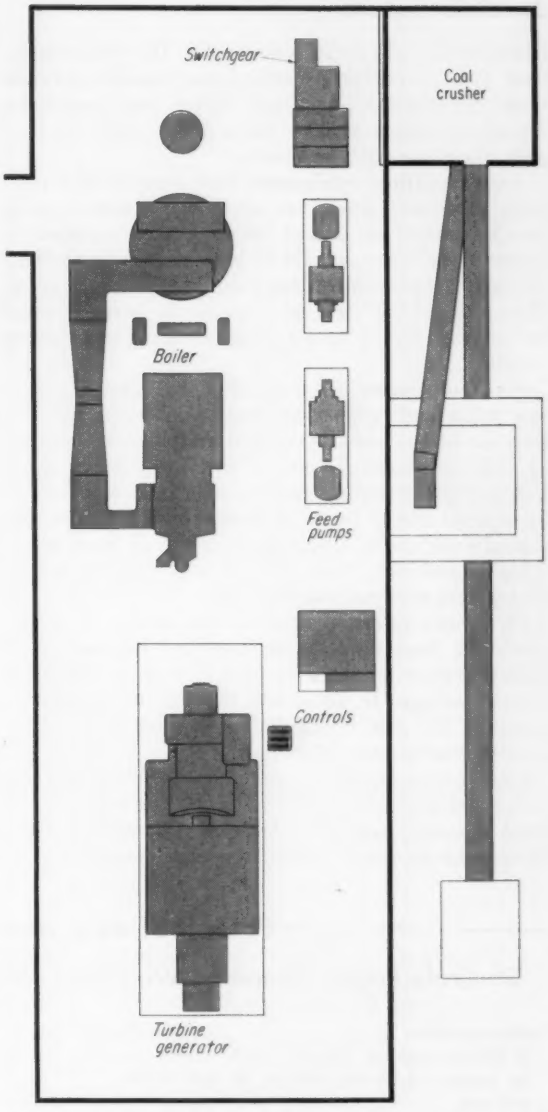
Old plant heat balance can get helping hand from closed feedwater heater operating on 30-psig extraction steam and heating feed for old No. 6 boiler. This one addition could decrease noncondensing generation and help eliminate venting of 30-psig steam during normal operation or breaks of paper on machines. Under these conditions heater would pay off in two years.

Selection of 400-psig turbine drive for the new paper machine went a long way toward restoring power balance. In summer three 125-psig 750-hp paper-machine turbine drives discharged more 30-psig steam to process than needed. So the 30-psig bleed point on No. 7 turbine was shut off. The new 400-psig 1800-hp turbine drive discharges less 30-psig steam than the smaller machine it replaced. This, coupled with added 30-psig process-steam load of new paper machine, can greatly increase noncondensing power by putting No. 7 turbine's unused bleed point to work.

Loading sequence entered the picture at this point, with unit efficiency taking a back seat to cost per kilowatt. As soon as we had determined characteristics of the new cycle we were ready to tackle the important problem of how to run the new unit and existing equipment most effectively. With overall cost as the criterion we recommended this loading sequence: (a) all available hydro power (b) No. 7 turbine-generator full extraction power (3) No. 4 turbine-generator noncondensing power to satisfy 125-psig process demands not carried by No. 7 (d) No. 9 turbine-generator (e) No. 8 turbine-generator (f) No. 7 turbine-generator as straight condensing power.



ELECTRICAL SYSTEM crossties new generator to 13.8 kv and 4160-v buses. Neutral of the 13.8-kv system has resistance ground



COMPACT LAYOUT cuts building costs to bone, places control center a few steps from boiler-turbine aisle and feed-pump valves

Unit loading during scheduled outages of new equipment poses a much more complicated problem. The new turbine-generator represents so large a block of the mill's firm power that production may be curtailed during outages. New equipment's size has no effect on this problem, and the condition will continue until the next unit goes in. Boiler outages cause less trouble since the emergency 400-psig steam line allows part-load operation of the new turbine. The logical time for any turbine outage would be early spring when hydro power should be at its maximum.

Plant layout gave us an opportunity to chalk up present and future cost savings. Our unit-cycle design allowed freedom to locate new equipment anywhere in the mill area. This was an immediate saving since expansion of present power plant would eat into already cramped manufacturing areas and wipe out existing coal-handling setup, and any future expansion would have killed additional manufacturing space.

We selected separate but adjacent space, allowing a sharing of some services, shorter piping and power lines, common coal storage and rail area, etc. This location permits expansion away from main plant, and step-by-step abandonment of old power plant to manufacturing.

Electrical distribution-transmission system typifies an industrial plant which has slowly added capacity as needed through the years. Initial hydro- and steam-generated power was 25 cycles. As plant grew 60-cycle equipment went in and portions of old system were converted to 60 cycles. At the time the new power plant went into operation, one hydro turbine at Grand Falls and one steam turbine generated 25-cycle current; one frequency-converter set also supplied 25-cycle power. Our long-range plans call for scrapping steam turbine and converting hydro unit, transformers, etc to 60 cycles. When done the mill will have duplicate 33-kv transmission lines at 60 cycle and fast-disappearing 25-cycle mill load.

New generator ties to 13.8-kv bus, above, and in parallel with No. 8 generator supplies power directly to grinder load. New unit crossties to 4160-v bus. Grounding ties got special attention because of possible high fault currents from 13.8-kv load. We planned future expansion to add electrical systems similar to the new unit and in parallel with it.

Compact equipment layout started with boiler and turbine facing common aisle, with auxiliaries tucked around them. Building width normally depends on boiler width, but the cyclone furnace we selected requires so little floor area that turbine base and condenser are wider. Rectangular floor plan can be repeated as mill expands.

Wherever possible auxiliary equipment is either at

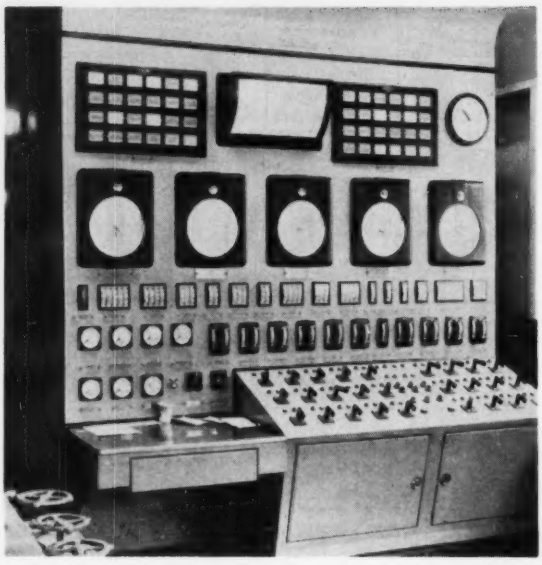
basement-floor or operating-floor level. This makes equipment more accessible, provides better foundation conditions and shortens piping and wiring interconnections. Equipment stands at floor levels above operating floor only where absolutely necessary.

Coal-handling equipment took some careful planning. Obviously, new conveyors would be wiped out by next expansion, but cost of installing final coal-handling system at the time could not be justified even on the basis of rising future construction costs. This concept of deliberately picking short-term usefulness actually saved the company money by not tying up capital in long-term payoffs.

Control center is on operating-floor level between new boiler and turbine-generator. Instruments and controls for boiler, turbine-generator and all auxiliaries are on this unit panel. Layout of major equipment items, instruments and controls gives operators maximum control over power plant. Heart of control system lies in unit control panel and in operating aisle, with all items within a few steps of each other—this will be particularly helpful to operators whenever troubles occur.

St. Croix's special position as the source of electric power for local residents of Woodland required us to include frequency regulation as a part of the generator control package. In all of our planning the concept of operating the new installation as a small utility plant governed our selection of controls.

After conversion of the remaining 25-cycle hydro generator and transmission system to 60 cycle we expect to finish supervisory-control installation at Grand Falls Dam. Then hydro plant will operate by remote control.



CENTRAL CONTROL places all important controls, indicators at operator's fingertips. Added recorders mount on back of cubicle

As this story went to press, we received word of a turbine-oil fire in St. Croix's new 12.5-mw power plant. When all facts are in, POWER will report further.

One thing is apparent. The isolated unit paid off since the old plant still carries mill load.

Principal new power-plant equipment

St. Croix Paper Company, Woodland, Maine: Turbine-generator No. 9, Boiler No. 7

Turbine-generator, 1 — Allis-Chalmers Mfg Co
12,500-kw capability, 850-psig 900-F throttle conditions, 1½-in. Hg exhaust, 13,529 kva, 0.85 pf, 60 cycle, 13,800 v, air cooled, 3600 rpm

Steam generator, 1 — Babcock and Wilcox Co
125,000 lb per hr, 875 psig, 900-F superheat. Indoor unit, coal fired by one 6-ft cyclone furnace and two full-capacity drag feeders, pressurized furnace, slag tap

Air preheater, 1 — Air Preheater Corp
20,400 sq ft, 310-F exit gas, including leakage, 150-F inlet air

Forced-draft blower, 1 — Westinghouse Electric Corp, Sturtevant Div
41,600 cfm at 54.8 in., 450 hp, 4160-v dripproof motor

Soot blowers, 10 — Diamond Power Specialty Co
7 retractable, 3 rotating-wall blowers

Condenser, 1 — Elliott Company
8500 sq ft, vertically divided waterbox, two pass, 81,500 lb per hr at 80-F water temperature

Circulating-water pumps, 2 — Ingersoll-Rand Co
5800-gpm each, 33-ft head, 60-hp 860-rpm drive

Condensate pumps, 2 — Ingersoll-Rand Co
Vertical, six-stage, 220-gpm each, 250-ft head, 25 hp, 1750-rpm drive

Feedwater heaters, 3 — Griscom Russell Co
Fourth-point heater: vertical U tube, Admiralty tubes, 6 pass, 7.5 psia, 548-sq-ft condensing, 65-sq-ft subcooling in drain cooler
Second-point heater: 90-10 Cupronickel tubes, four pass, 121 psia, 527-sq-ft condensing, 89-sq-ft subcooling
First-point heater: 90-10 Cupronickel tubes, four pass, 277 psia, 375-sq-ft condensing, 43-sq-ft subcooling

Deaerating heater, 1 — Cochrane Corporation
130,000 lb per hr, vertical tray, horizontal tank, internal-vent condenser, 30,000-lb storage capacity

Boiler-feed pumps, 2 — Ingersoll-Rand Co
150,000 lb-per-hr net after recirculation, 1121-ft head, 3500 rpm eight-stage, 254-F water temperature

Chemical-feed system — Milton Roy Co

Air compressors, 2 — Worthington Corporation
Aspirating-air compressor: 440 cfm, 80 psig, air-cooled, 100 hp
Instrument-air compressor: 91 cfm, 100 psig, water-cooled

Coal conveyors — Stephens-Adamson Mfg Co

Coal crusher, 1 — Pennsylvania Crusher Div, Bath Iron Works
60 ton per hr, 0- to ¼-in. discharge, 125 hp, 1200-rpm drive

Ash conveyor, hydraulic — Allen-Sherman-Hoff Co

Slag tank, 1 — Allen-Sherman-Hoff Co

Station service transformer — General Electric Company
13,800/4160 v, 2000 kva

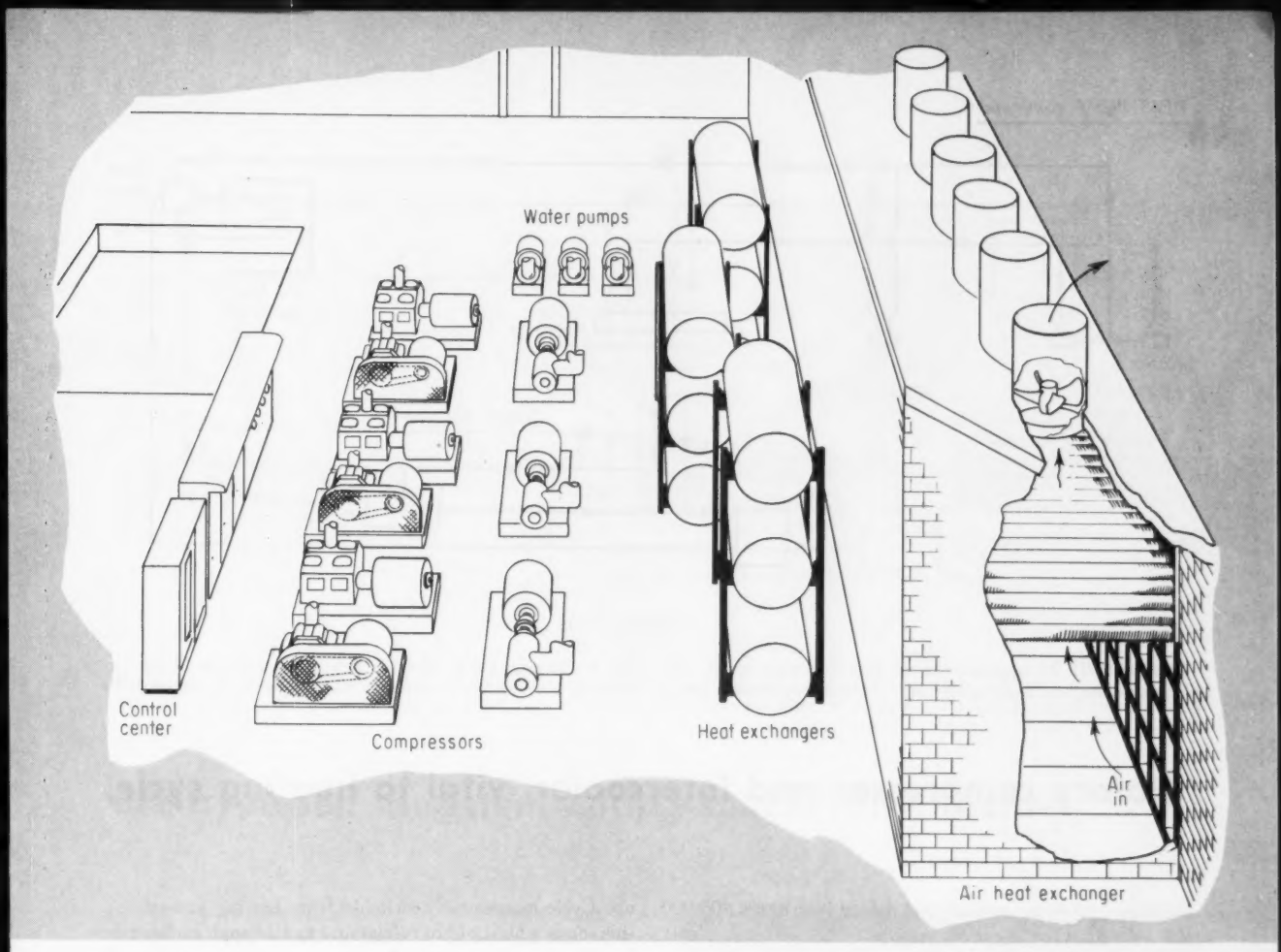
Main switchgear — General Electric Company

Combustion control — Bailey Meter Company

Flame-failure monitor — Fireye, Combustion Control Corp

Control panel construction — The Whitmor Company Inc

Consulting engineers — Chas T Main Inc



THREE HEAT PUMPS fit into 50x50 space, about 10% of plant area, in Flick-Reedy Corp factory in Bensenville, Illinois. Heating requires 300 compressor-hp maximum from each pump, while 175 hp are needed in summer. Outside air is heat source and sink

Three-unit heat pump heats and cools 220,000-sq-ft plant near Chicago. Costs are same as boiler-absorption machine combination, with added advantage that . . .

Heat pump keeps plant all-electric

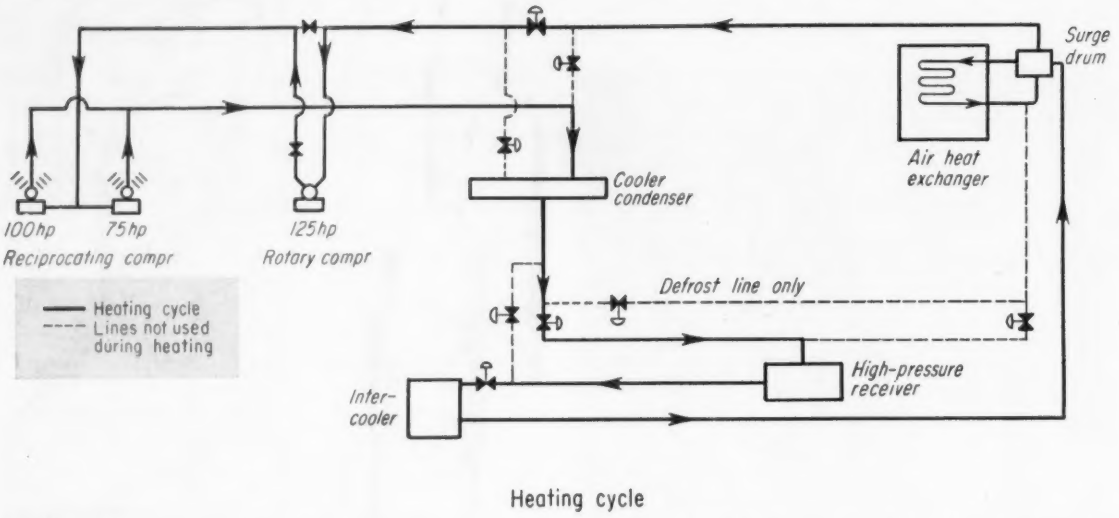
Last winter a heat pump started taking Btu's from outside air and using them to heat a factory in a Chicago suburb. During the summer, heat pump will cool this completely air-conditioned 220,000-sq-ft plant. System's compressors, fans and water pumps use up 1200 horsepower, take care of a 5,500,000 Btu-per-hr heat load. Cooling chore adds up to 627 tons.

Reasons for selecting heat pump involved more than purchase price and operating expense. Power source and space were also key factors. When first costs of pump and an oil-fired boiler-absorption machine combination were compared combination won. Pump cost $540,000; bid for combination was $500,000. But on power costs the pump won: estimates put electricity tab for pump heating at $7200, oil bill at $12,000 for a typical heating season. Amortization charges cancelled out the difference.

Power-services simplicity helped swing the decision to the heat pump. All plant's production operations are electrically powered and heat pump maintains that pattern. Keeping other fuels out of building dropped insurance rates and avoided oil-fired equipment maintenance. Finally, the heat pump took less space. Combination needed 3500 sq ft, pump only 2500 sq ft for an erection-cost saving of $8750 at $7 per sq ft.

Low electric bill results from heat pump operating at bottom of utility rate structure. The plant, part of Flick-Reedy Corp, turns out air and hydraulic cylinders and seal type pipe fittings. Manufacturing operations include heat treating, plating, welding, painting and precision machining. They all need current, creating a sizable electric bill. So heat-pump system runs on low-cost power.

Design points for heat pump are widespread: –10 F



REFRIGERANT 22 evaporates in air heat exchanger at 2.7 psig, –35 F, taking heat from outside air. Two-step compression boosts gas to 229 psig, 110 F. Hot gas liquefies in condenser, heats circulating water before it passes to various ductwork fan-coil units

Rotary compressor and intercooler, vital to heating cycle,

in winter, 95 F in summer. Total heat loss hits 6,200,000 Btu per hr when ambient air drops to –10 F. Lights supply part of heat makeup, heat pump the rest. Although the lights put out 1,000,000 Btu per hr only 70% of this was applied as a credit in sizing the system. In summer, lights are a drawback. Here they add their full 1,000,000 Btu per hr output and help to boost plant cooling load to 627 tons.

Equipment. Heat pump in this plant is actually not one large system. Instead, York Corp put in three smaller heat pumps side-by-side, each rated at slightly over 200-tons cooling capacity.

Three compressors form the core of each heat pump; they supply Refrigerant 22 to cooler-condenser and air heat exchanger. Balance of equipment for each unit system includes: two 44,000-cfm axial-flow fans (outside building); an intercooler to precool refrigerant during heating cycle; a high-pressure refrigerant receiver; surge tank; a 330-gpm circulating-water pump.

Control system is pneumatic. Signal for automatic switching from cooling to heating cycle or reverse and for temperature control of either cycle comes from thermostat outside building.

Main heat exchangers have dual purpose. The cooler-condenser, spotted inside the building, heats circulating water in winter, cools it in summer. Air heat exchanger transfers heat between outside air and refrigerant, using air as heat source in winter and sink in summer. Exchanger is outside building wall, screened from view by brick latticework, right. Axial-flow fans over exchanger pull air through lattice, up over finned coil bank, then push it to atmosphere.

Heat-transfer direction in air heat exchanger is reversed in winter now and then to relieve coils of ice build-up. Cycle momentarily switches from heating to cooling; this sends a blast of hot refrigerant gas through exchanger, knocking ice from coils. Ice drops on electrically heated rubber pads, melts, and drains.

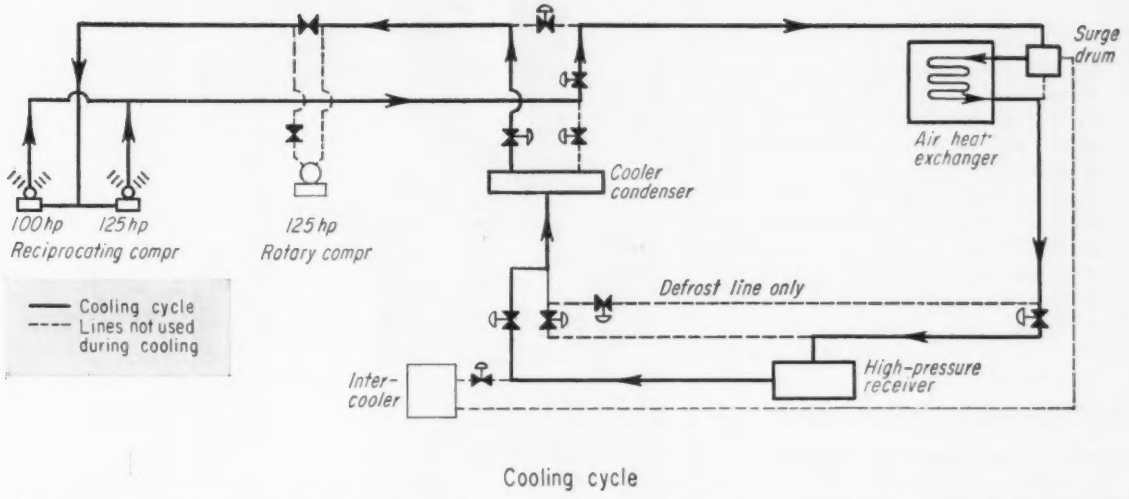
Static pressure-sensing elements between coils and fans automatically start and stop defrosting cycle; while defrost cycle is in effect on one heat pump, the other two pumps maintain building temperatures at desired levels.

Air distribution. Fans in fan-coil units each push 21,000 cfm of conditioned air to factory and office areas. Coil units serve from one to sixteen zones. Air travels through rectangular ducts at 1600 to 1800 fpm to conditioned areas; it returns to coil units by way of a plenum formed by ceiling and peaked roof. Heat gain and loss in plenum is kept to a minimum by 1½ inches of glass-fiber insulation attached to the roof's underside. Aluminum foil backing the insulation acts as a vapor barrier.

Not all conditioned air returns to coil units. Welding and paint operations contaminate the air, so air passing through these areas exhausts directly to atmosphere. Maximum recirculation for air that does return is 80 to 83%. Percentage is limited by state law that requires at least 17% ventilation air mixed with return air.

Cycles. Schematics, above, outline heating and cooling cycles. Some piping is common for both cycles, other runs are used for heating or cooling but not both.

During heating cycle heat flows from outside air to Refrigerant 22 in air heat-exchanger coils. Liquid refrigerant enters coils at 2.7 psig, –35 F, turns to gas as it picks up 84 Btu per lb of refrigerant. It then passes to rotary compressor inlet. Discharge from rotary compressor at 43 psig, 45 F (including superheat) enters reciprocating compressors. Here final compression feeds the hot gas at 229 psig, 110 F to the cooler-condenser.



COOLING CYCLE works between 69 psig, 40 F and 229 psig, 110 F. Here circulating water gets heat from plant air, loses it to evaporating refrigerant in cooler-condenser. Following single-stage compression gas passes to air heat exchanger, is cooled by outside air

are bypassed in system during summertime cooling

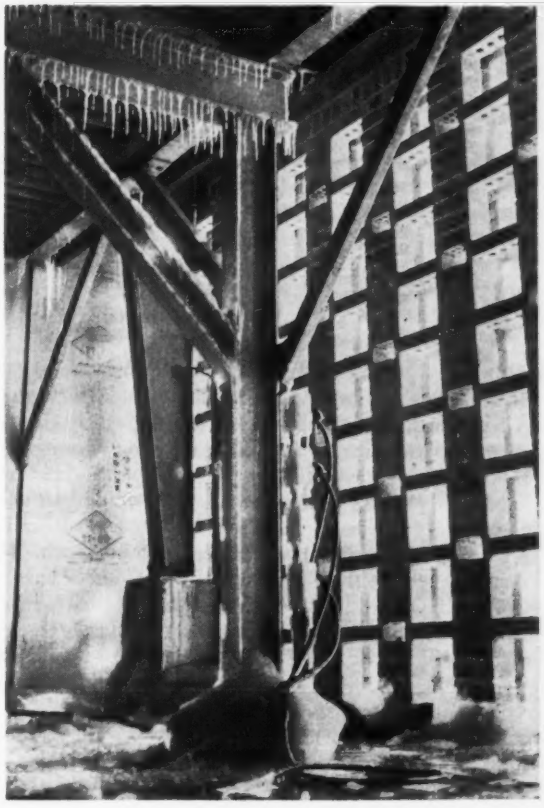
The two reciprocating compressors of each pump are in parallel with each other and in series with the rotary unit and main exchangers. Outside temperatures determine whether one of these reciprocating units works alone or both work at the same time.

Refrigerant liquefies in cooler-condenser during heating cycle. Process releases 86 Btu per lb of refrigerant to warm circulating water. Before going back to the air heat exchanger, the again-liquid R-22 flows to high-pressure refrigerant receiver and is then precooled to 30 F in the intercooler. Finally it reaches the expansion valve. At this point the cycle is ready to start again.

Cooling cycle cuts out intercooler and rotary compressor. This time heat source is air inside plant. Refrigerant evaporates in cooler-condenser at 69 psig and 40 F, cooling the circulating water. Reciprocating compressor takes gas from cooler, boosts pressure and temperature to 229 psig and 110 F and pushes gas on to air heat exchanger. Here heat is dumped to outside air as gas condenses.

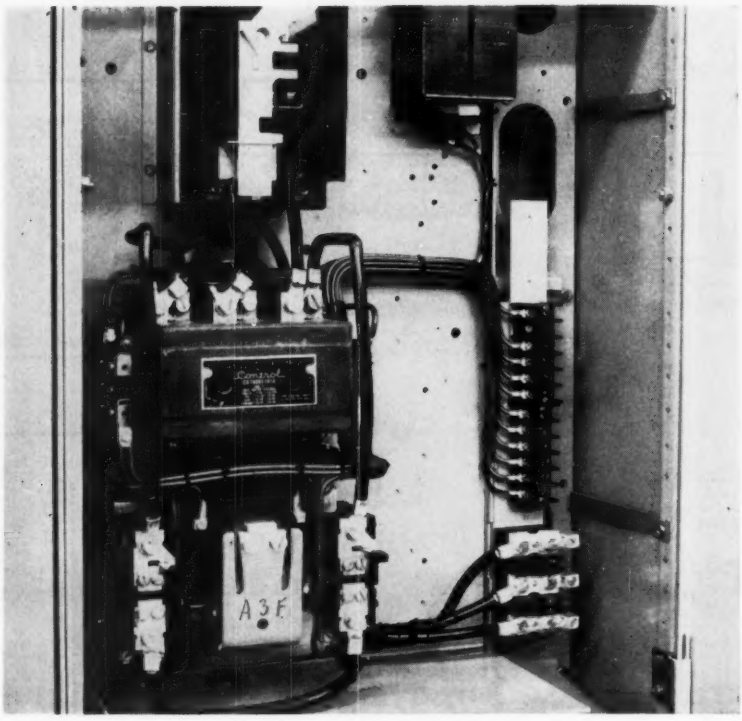
Water supply is a novel feature of the plant. Two man-made lagoons, designed for beauty and utility, collect drainage from plant roof and ten acres of parking areas. Rainfall in normal years will supply 150-gpm industrial water and 30-gpm makeup water during summer cooling cycle, but water system is hooked to city supply in case there's an extended drought. Otherwise the only outside power service the plant depends on is electricity. Two primary substations on plant property, fed by different power plants, give added protection and insurance of continuous electric supply.

All equipment in system is standard, simplifying spare-parts problem. Flick-Reedy also elected to sign a maintenance contract to lessen their air-conditioning worries.



FANS pull air through brickwork, over coils and out to atmosphere. Heated pads melt ice dropped from coils during defrosting

Thermal relays are standard overload devices for motor protection today, but under different operating conditions the degree of protection given the motor can vary considerably



OVERLOAD RELAY has heat-responsive mechanism and heater calibrated to load current

Select thermal-overload relays to match your motor conditions

By R W BROKAW, General Electric Co

Motor overload protection is intended primarily to protect the windings from heating effects of excessive current. Device normally used is an indirectly heated thermal relay with replaceable heaters which is uncompensated for ambient temperature. Relay trips when design temperature of the heat-sensitive element is reached. How well the relay's response corresponds to conditions within the motor depends on selection of the proper relay.

Overload heaters must be rated or set at not more than 125% of motor full-load current rating for 40-C rise motors and not more than 115% for all others, according to *National Electric Code*, Section 4322. (In following discussion motor insulation is considered Class A, motor and relay ambient 40 C unless otherwise noted.)

Motors rated 40-C rise can operate at 115% full-load current (flc) continuously without exceeding motor temperature limits because of 15% service factor. Motors with 50-C or 55-C rise have no service factor. Therefore lower limit of the overload heater is 115% motor flc for 40-C rise motors and 100% motor flc for 55-C rise motors. Overload heater tables are set up with flc ranges to meet NEC requirements for an upper limit and motor operating ability for a lower limit. This means that the heater rating for a 40-C rise motor falls between 115 and 125% flc, and for a 55-C rise motor between 100 and 115% motor flc. The heater tables are usually set up so that rating increases in steps of about 10%.

Temperature limits of motors are defined in *AIEE Standard No. 1* which states that Class A insulation has a *hottest-spot* temperature limit of 105 C. Hottest-spot temperature is not directly measurable but is arrived at by adding an experience-based allowance to a measurable temperature. The limit of 105 C for Class A was established empirically to provide seven years of continuous operation at full load and 40-C ambient. Since life of Class A (organic) material depends on both time and temperature another temperature limit could have

Performance of thermal relays depends on operating variables

been set with a different life expectancy in view. Life of insulation is cut in half for each 8- or 10-C rise.

Select overload heaters directly from heater tables when you know flc and temperature rise of the motor. When motor data isn't available choose heaters on basis of handbook values of flc for 1800-rpm 55-C rise motors. If motor happens to have 40-C rise it will be overprotected since the heater doesn't allow for the 15% service factor. However, if the practice were to select heaters based on 40-C rise motor currents a 55-C rise motor would be underprotected.

Overload-heater tables for motor-control centers and other enclosures have been based on the enclosed rating, recognizing that ambient inside the control center is usually higher than 40 C. This is less conservative than former practice but has pretty much eliminated nuisance tripping which had been experienced.

Performance of overload relays depends on operating variables. If special operating conditions exist extra care must be exercised when selecting relays. If the motor must operate overloaded for a period of time, perhaps due to low line voltage, you can install larger heaters. But you must realize that the life of the motor insulation will be shortened. Under steady-state conditions motor temperature rise varies about as the square of the load current.

High ambient temperature resulting from a constant heat source such as a boiler or an intermittent heat source like sunshine upsets relay performance. Effects of high ambients are shown in graph, p 80. If the high ambient is constant you can compensate for it and provide proper protection with an oversized heater. Pick derating factor from curve or use rule of thumb: increase heater-current value about 8% for each 10-C rise in ambient temperature above 40 C, up to 60 C. If high ambient is intermittent an ambient-compensated relay is your best solution. These relays aren't perfectly compensated, however, as you can see from curve, p 80. Under extreme conditions some nuisance tripping may still be experienced.

Long accelerating time can trip normal relays. Common practice is based on a ten-second maximum motor acceleration. For longer periods check with control manufacturer's engineers. Often a long-trip relay solves the problem. But these relays are relatively large and often there isn't room to mount them in a standard starter compartment. Where accelerating time is longer than about 25 seconds you may have to go to a special overload-protection circuit. Other factors can be involved, including whether allowable stall time is greater or less than accelerating time.

Repetitive-duty cycle makes it difficult to protect the motor since heater tables are set up on continuous-duty basis. Best solution in many cases is to put in a heater just large enough to ride through. In other cases you may find that you have to resort to special protective schemes.

Abnormal conditions may exist which you don't recognize or perhaps misunderstand. They can interfere with proper relay performance. Intermittent abnormal starting or running conditions can cause the relay to trip. One example is cooling-tower fans windmilled in the opposite direction on windy days — when fan motors are started they first have to stop the windmilling, then start the fan in the correct direction.

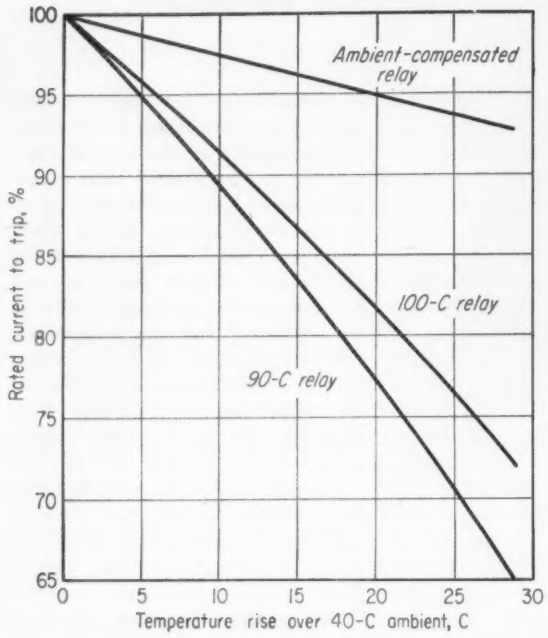
For various reasons some motors will draw a higher flc than is indicated by handbooks so that relays may trip under normal operating conditions. When you've made sure motor isn't overloaded, select a larger heater to compensate for this. Keep in mind also that occasionally a relay in a 40-C ambient will trip with no overload just because the manufacturer's tolerances on the heater-relay combination add up in the negative direction. This is most likely to happen when the heater rating of a 55-C rise motor falls close to the motor flc. Another heater of the same rating may solve the problem, or you may need the next size.

Limitations of thermal-overload relays include the basic one that they attempt to determine motor heat by measuring current at a remote location. Standard overload relays have certain additional limitations which you should consider when you use them. The relay-heater combination protects against overloads up through locked-rotor conditions. The resistance-heating type is self-protecting up to ten times heater rating, which could be as much as 12.5 times motor flc. Greater currents may burn out the heater before heat can transfer to the mechanism and raise its temperature enough to trip. If a heater does melt in a relay, replace the relay; its time-current curve will generally have changed. To avoid heater failure select circuit breaker or fuse to remove short-circuit current before heater reaches melting point. Some relays utilize induction heating and can stand considerably higher current than relays using resistance heaters.

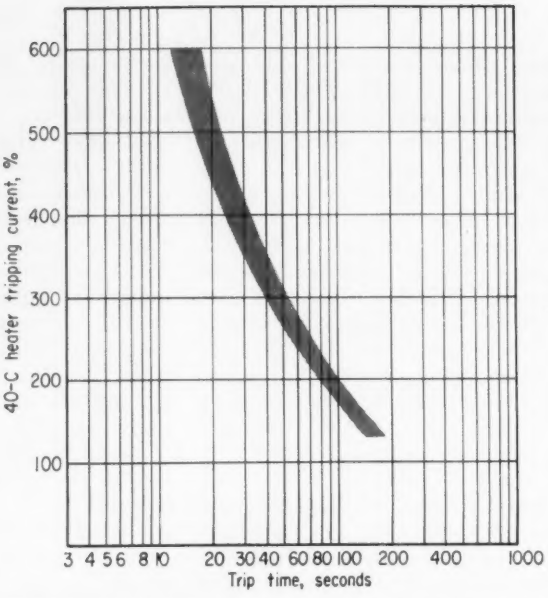
Adjustable overload relays on 55-C rise motors can help eliminate nuisance tripping. Adjust the relay to put rating in the top portion of the range allowed by NEC (115% flc) by this method: (1) Select heater or coil by motor flc from table of heaters or coils for 40-C rise motors. (2) Calculate maximum relay rating permitted in the NEC by multiplying motor flc by 1.15. (3) Calculate relay settings by dividing the maximum rating permitted under the NEC by the rating of the heater or coil selected and set the relay adjustment at this percentage value. For example: Full-load motor current = 8.5 amp. Coil selected for relay is rated 10 amp. Maximum rating permitted by NEC is 1.15 x 8.5 = 9.78 amp. So relay adjustment setting = 9.78/10 = 0.978 or 97.8%.

Class B insulation of motors is used in some installations. Here are some of the more common reasons for using Class B insulation together with comments on how to select the overload heaters:

(1) *Motor is in an unusually high ambient.* Some motors are installed in areas where it's impossible or impractical to keep ambient temperature down to 40 C—an oil field in a hot climate is an example. For such installations the higher Class B hot-spot limitation of 130 C is taken up by the higher ambient. From the motor standpoint no additional rating is given to the heater. From the relay standpoint consider the ambient sur-



HIGH AMBIENT TEMPERATURES (above 40 C) derate thermal relays; even ambient-compensated relays undergo trip-current change



TIME-CURRENT CURVE of typical thermal-overload relay is a narrow band. Use overload relays in conjunction with fuse or breaker

rounding the relay—should ambient compensation be used or an adjustment be made in the heater size.

(2) *Motors with smaller frame sizes are advantageous.* There are many applications of motors where physical size is a limiting factor. For such applications Class B insulation offers a solution by providing a given horsepower rating in a smaller frame size. For these motors the hot-spot temperature limit will be reached in a 40-C ambient under normal operating conditions. You can choose heaters for these motors directly from the tables.

(3) *Conservative practice is your operating philosophy.* A few users specify Class B insulation on motors merely as a conservative practice. It is possible under normal operating ambients to allow more load current before the 130-C temperature limit is reached. Thus the heater can be larger than normal and still protect the motor. Since heater's basic function is motor protection, this is a reasonable approach. However, you may want to follow a consistently conservative policy and decide that any motor current above rated load represents an abnormal condition which should be investigated.

When you want to take advantage of the extra permissible load and normal ambient temperatures are encountered, select the larger heaters by multiplying motor flc by 1.2 for open motors and 1.1 for enclosed.

Analysis of your motor-protection problems on the bases so far outlined should provide desired protection and keep nuisance tripping to a minimum. One note of caution may be in order at this point—heaters must be selected from tables that apply to your particular controller. There are many heater tables published for different types of equipment, and the ranges of motor current for a given heater will vary widely among the various tables.

To complete the picture let's take a look at conditions usually prevailing in motor applications. These are more favorable than the extremes which we have had to consider so far. Favorable operation conditions explain why relays don't trip more often than they do in spite of frequent lack of correct motor data. Among favorable conditions encountered are these:

(1) *The 15% service factor* in a 40-C rise motor is seldom taken into account in applying the motor. Combined with an average heater rating of 120% flc this reserve factor often balances out higher ambient temperatures, low manufacturing tolerances.

(2) *Heaters for 55-C rise motors have 5% more range* than those for 40-C rise motors, that is, 10% over continuous rating for 40-C rise motors as against 15% over continuous rating for 55-C rise motors. So the average heater rating for 55-C rise motors will be 107.5% of full-load current, which will balance out some of the negative factors.

(3) *Ambient temperature often isn't 40 C.* Heater tables are based on a 40-C ambient, while many installations are in a considerably lower ambient temperature. This gives a heat reserve which can balance out another factor of unfavorable character.

(4) *Motors often are not operated at rated load.* Motors come in certain set horsepower ratings while the requirements of mechanical drives can fall anywhere. It has been estimated that in a typical industrial plant motors are operated at an average of only 80% of rating. Lower values of operating currents have a large effect upon the heat generated from heaters because of the I^2 factor. For example, a current of 80% full load would generate only 64% of the normal heat. This of course reflects a load reserve which is available in the motor itself.

By C R KISE, P E, Baldwin-Hill Co

This month we end our discussion of simplified methods for calculating heat loss from insulated surfaces. If you're dealing with piping, here's the lowdown on how to . . .

Block heat loss from cylindrical surfaces

Continuing last month's discussion let's look at an example which modifies the procedure of calculating heat loss through a compound-insulated plane surface.

Example I: Heat loss from our indoor furnace (May 1959, p 73) is to be further reduced by adding a layer of low-temperature insulation on top of the 2-in. thick material. The outer insulation is to be 1-in. thick, with a k factor of 0.34 at 200 F, 0.42 at 300 F and 0.50 at 400 F.

Curve for surface heat loss has already been established, but obviously will have to be extended downward.

From Fig. 1 and 2 at $t_s = 160$ F:

$h_r = 1.21$
$h_c = 0.71$
$h = 1.92$
$q = 154$

Plot this point (Fig. 8, point F) and draw lower portion of the curve.

Temperature drop through each material is proportional to the resistance of that material. With this in mind, proceed to work as follows:

(1) Make a rough estimate of individual and total resistances to approximate the temperature drop through each material. Given data indicates that the split will be something like this:

Material	Thickness x	k factor	Resistance $R = x/k$
Inner	2 in.	0.6	$3.33 = R_1$
Outer	1 in.	0.4	$2.50 = R_2$
			$5.83 = R$

Ratio of the temperature drop through the first material to the total temperature drop will be the same as the ratio of material's resistance to total resistance:

$$\frac{\Delta t_1}{\Delta t} = \frac{R_1}{R} = \frac{3.33}{5.83}$$

(2) Now let's assume a surface temperature of 200 F. Then:

$$\Delta t = t_i - t_s = 1000$$

$$\Delta t_1 = \Delta t \frac{R_1}{R} = 1000 \times \frac{3.33}{5.83} = 571$$

Interface temp = 1200–571 = 629

The mean insulation temperatures:

$$\text{Inner material} = \frac{1200 + 629}{2} = 915$$

$$\text{Outer material} = \frac{629 + 200}{2} = 415$$

(3) With this information we can refer to the k factor curves for conductivity data and make a more educated guess as to the resistance and temperature drops.

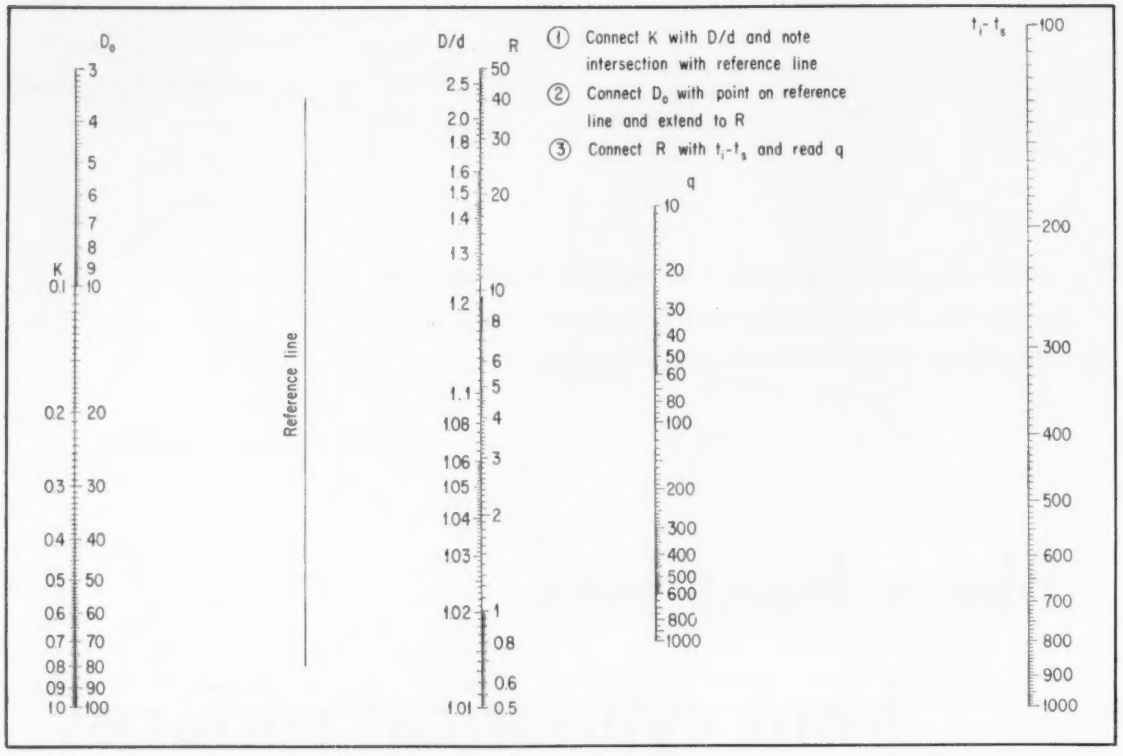
Material	Mean temp	k factor	x	$R = x/k$
Inner	915	0.712	2 in.	2.81
Outer	415	0.512	1 in.	1.95
				4.76

Substituting in our basic formula:

$$q = \frac{t_i - t_s}{R} = \frac{1000}{4.76} = 210$$

Plot this point on the graph (Fig. 8, point G), 210 Btu at 200 F.

(4) Since this point falls to the right of the curve, our next point should be at a lower assumed value of t_s. Let's assume $t_s = 170$ and use the


D₀
K
Reference line
D/d
R
q
t_i - t_s
① Connect K with D/d and note intersection with reference line
② Connect D₀ with point on reference line and extend to R
③ Connect R with t_i - t_s and read q

11 This nomograph is based on a formula which evolves heat-transfer rate—heat loss, Btu per hr per sq ft of surface—by taking into account external diameter and ratio of outer and inner diameters of the insulation of piping and cylindrical vessels

resistance values from Step (3) to find closer values for the mean insulation temperature.

$\Delta t = 1200–170 = 1030$

$\Delta t_1 = 1030 \times \frac{2.81}{4.76} = 608$

Interface temperature = 1200–608 = 592

Mean insulation temperatures:

Inner material $= \frac{1200 + 592}{2} = 896$

Outer material $= \frac{592 + 170}{2} = 381$

(5) Again refer to the k factor curves and tabulate:

Material	Mean temp	k factor	x	$R = x/k$
Inner	896	0.696	2 in.	2.88
Outer	381	0.486	1 in.	2.06
				4.94

Substituting this value:

$q = \frac{t_i - t_s}{R} = \frac{1030}{4.94} = 209$

Plot 209 Btu at 170 F on the graph (Fig. 8, point H) and connect this point with point G. The line GH intersects surface heat loss curve at t_s = 183 F and q = 209 Btu. A final check can be made at this point.

Some problems involve three or more thicknesses of different materials. In such cases:

$$q = \frac{t_i - t_s}{R_1 + R_2 + R_3 \, etc} = \frac{t_i - t_s}{\frac{x_1}{k_1} + \frac{x_2}{k_2} + \frac{x_3}{k_3} \, etc}$$

Problems of this type are solved in the same way as our example, above. Just remember that temperature drop through each material is equal to total temperature drop times ratio of resistance of material to total resistance.

Cylindrical surfaces. Now let's take a look at the important case of heat transmission through insulation on pipes or other cylindrical surfaces which offer a diverging path for heat flow. Formulas become more complicated than for plane surfaces. They may be expressed either in Btu per ft of pipe or Btu per sq ft. Heat flow through the insulation must be balanced against combined radiation and convection loss from the surface to atmosphere. Since our previous data and alignment diagrams for surface heat loss are on a square foot basis we'll keep our pipe-insulation calculations on the same basis so that we can make direct comparisons. This means that we'll still be working with the basic formula expressing heat flow per sq ft of external surface as:

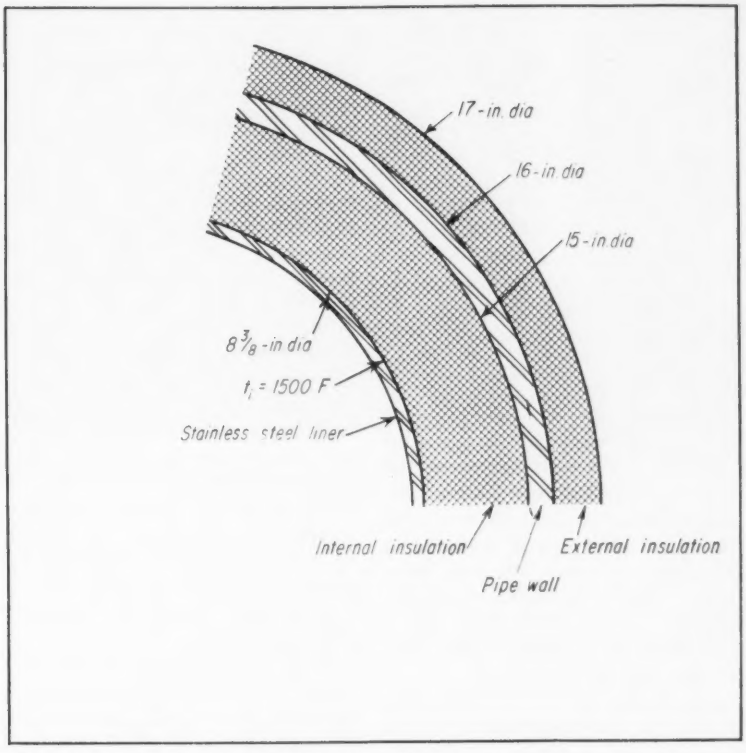
$$q = \frac{\Delta t}{R} = \frac{\Delta t}{\left(\frac{x}{k}\right)}$$

Because of the divergent heat path we can no longer use the actual thickness, x, of the insulation. We must substitute an expression for equivalent thickness, x_e, which takes into account the external diameter D_o and the ratio D/d of insulation's outer and inner diameters.

$x_e = 1.1513 \, D_o \log D/d$

Therefore:

$$q = \frac{\Delta t}{\left(\frac{1.1513 \, D_o \log D/d}{k}\right)}$$



12 If two or more layers of insulation have different conductivities, ratio of inner and outer diameters and resistance of material is calculated separately for each layer

Alignment diagram, Fig. 11, is based on this formula. It not only minimizes calculations but also eliminates the need to work with logarithms. To use the nomograph, first calculate by slide rule the ratio D/d (insulation's OD divided by its ID). Then list basic data and proceed:

(1) Connect k factor with D/d and note point of intersection with reference line.

(2) Connect this point with D_o and extend to R.

(3) Connect R with t_i–t_s and read q in Btu per sq ft of external surface. Or, if desired, use slide rule to find $q = (t_i - t_s)/R$.

Now let's see how this works.

Example II: A 6-in. pipe carrying steam at 250 F is to be covered with 1-in. thick insulation of conductivity shown by curve *J* in Fig. 7 (May 1959, p 72). Find the surface temperature and heat loss for a horizontal run operating indoors with 80-F ambient still air.

(1) Establish a curve for heat loss:

Points on curve	A	B	C
Assume: t_s	100	120	140
t_a	80	80	80
t_s–t_a	20	40	60
h_r (from Fig. 1)	1.03	1.09	1.15
h_c (from Fig. 2, 3)	0.61	0.71	0.79
h	1.64	1.80	1.94
$q = h\ (t_s - t_a)$	33	72	116

(2) Plot these points on a graph similar to Fig. 8 and draw a smooth curve through them as in previous examples.

(3) Find heat transmitted through insulation for $t_s = 120$:

$t_i = 250$
$t_s = 120$
$t_i - t_s = 130$
$t_i + t_s = 370$
$t_m = 370/2 = 185$
k (from Fig. 7) $= 0.40$
$d = 6.625$
$D = 8.625$
$D/d = 1.3$
$R = 2.8$, $q = 46$ (From Fig. 11)

Plot this point, 46 Btu at 120 F.

(4) This point falls to the right of the surface loss curve, so try using:

$t_s = 100$
$t_i - t_s = 150$
$t_i + t_s = 350$
$t_m = 175$
$k = 0.395$
$q = 52$ (From Fig. 11)

Plot 52 Btu at 100 F.

(5) Connect the last two points with a straight line. Our curve for surface heat loss is too high, but can be extended to find the answer at approximately 109 F and 49 Btu per sq ft.

(6) This can be converted to Btu per ft of pipe on the basis of 8.625-in. diameter. From Fig. 6 we find that the area is approximately 2.25 sq ft per ft of pipe.

Compound insulation. Fig. 11 can also be used for pipe having two or more layers of insulation with different conductivities. In such cases the ratio D/d and the resistance are calculated separately for each layer. D_o, however, is always the diameter of the external surface. Let's try an example to help clarify the procedure.

Example III: A line to carry superheated steam at 1500 F is to be internally insulated so that ordinary carbon steel can be used for the piping. A thin external insulation will also be used to further reduce heat loss and to maintain pipe-wall temperature well above the condensation point. Fig. 12 illustrates this construction. Insulating materials have conductivities as listed:

Internal insulation

	A	B	C
t_m	800	950	1050
k factor	0.74	0.87	0.96

External insulation

	A	B	C
t_m	300	400	500
k factor	0.38	0.42	0.46

Find the surface temperature and heat loss based on average ambient conditions of 60 F and 10-mph wind.

(1) Start as usual by establishing the curve (as in Fig. 8) for surface heat loss vs surface temperature.

	A	B	C
Assume: t_s	100	120	140
t_a	60	60	60
t_s–t_a	40	60	80
h_r (from Fig. 1)	0.972	1.031	1.093
h_c (from Fig. 4)	3.4	3.42	3.46
h	4.372	4.451	4.553
$q = h\ (t_s - t_a)$	175	267	364

continued

(2) Line up data for calculating heat transmission through insulation:

(a) Draw k factor curves for internal, external insulations (k_1, k_2).

(b) Note diameters and ratios: $D_o = 17$

$$D/d \text{ (internal)} = \frac{15.25}{8.375} = 11.82$$

$$D/d \text{ (external)} = \frac{17}{16} = 1.062$$

(3) Again make use of the fact that temperature drop through each material is proportional to the resistance of that material. Refer to the k factor curves for a first approximation of conductivities. Then use Fig. 11 to find the resistances:

Internal: For $k = 0.9$, $R_1 = 5.6$

External: For $k = 0.4$, $R_2 = 1.27$

Total resistance R is 6.87. Then:

$$\frac{\Delta t_1}{\Delta t} = \frac{R_1}{R} = \frac{5.6}{6.87} = 0.815$$

(4) Assume a surface temperature of 120 F. Then:

$\Delta t = t_1 - t_s = 1500 - 120 = 1380$,

and $\Delta t_1 = \Delta t \times \frac{R_1}{R}$

$= 1380 \times 0.815 = 1125$

Pipe temp $= 1500 - 1125 = 375$

Mean temperature and k factors:

$$\text{Inner material} = \frac{1500 + 375}{2} = 938$$

($k_1 = 0.86$)

$$\text{Outer material} = \frac{375 + 120}{2} = 248$$

($k_2 = 0.36$)

(5) Use Fig. 11 again with these new k factors to get: $R_1 = 5.9$; $R_2 = 1.42$ and $R = 7.32$. Then:

$$q = \frac{t_1 - t_s}{R} = \frac{1380}{7.32} = 189$$

Plot this point on the graph. The $t_1 - t_s$ scale of Fig. 11 goes only to a maximum of 1000. But chart can be used for higher values by multiplying both $t_1 - t_s$ and q scales by 10.

(6) Point just plotted on the graph falls to the right of surface loss curve, so take the second trial at $t_s = 100$ and $t_1 - t_s = 1400$.

$$\Delta t_1 = 1400 \times \frac{R_1}{R} = 1400 \times \frac{5.9}{7.32} = 1130$$

Pipe temp $= 1500 - 1130 = 370$

Mean temperature and k factors:

$$\text{Inner material} = \frac{1500 + 370}{2} = 935$$

($k_1 = 0.86$)

$$\text{Outer material} = \frac{370 + 100}{2} = 235$$

($k_2 = 0.355$)

From Fig. 11: $R_1 = 5.9$; $R_2 = 1.43$; $R = 7.33$. Then:

$$q = \frac{1400}{7.33} = 191$$

Plot 191 Btu at $t_s = 100$.

(7) Connect the last two points plotted and find intersection with the surface-loss curve at approximately 103-F surface temperature and 190 Btu per sq ft.

Pipe-wall temperatures. In these examples it has been assumed that the temperature of the pipe or vessel wall is uniform through its thickness. Actually there is a slight drop through the wall but the amount is negligible in ordinary problems involving insulation. Where the pipe wall is very thick it may be desirable to check this point, particularly if the heat-transfer rate is high.

Fig. 11 can be used to determine Δt through the pipe wall in exactly the same way as finding Δt through insulation. Metal conductivities are very high, far beyond the range of the k scale. The latter scale, however, can be multiplied by 10, 100, or 1000 providing the R scale is *divided* by the same amount. Be sure to use conductivities for a thickness of one inch. If the published data happens to give k for a length (thickness) of one foot, the given figure should be multiplied by 12 to get k 1-in. thick.

In our last example we specified *internally* insulated piping to permit use of ordinary carbon-steel material with superheated steam at 1500 F. This is a solution for handling hot gases under pressure which is becoming more and more popular in industry. Mild carbon steels lose strength rapidly at temperatures above 650 F and their use above this temperature is limited. For operations involving pressure at temperatures above 650 F special steels must be used. The higher the pressure and temperature the more "special" the steel and the greater the required wall thickness. As steel becomes more special and walls heavier, material and fabrication costs increase sharply. And excessive thermal expansion of all steels at higher temperatures, especially chromium-nickel steels, adds complication and expense in providing for expansion movements.

Internal insulation places a thermal barrier between the high-temperature flowing gas and containing pipe or vessel wall but allows pressure to be transmitted to the wall. By thus separating effects of temperature and pressure, manageable weights and thicknesses of carbon-steel walls can be used. Such internal thermal insulation keeps the pipe wall comparatively cool so that its full strength is available to withstand the pressure. In many cases this eliminates the need for alloy or stainless steels. In cases of extremely high pressures and temperatures use of internal insulation may be the only solution for installations which might be otherwise impossible to build because of the strength limits of even the best grade of stainless steels.

No general statement can be made about the relative economic merits of externally vs internally insulated construction since each will depend upon the particular application. But it may be generally stated that at temperatures above 1100 F the possibility of using internal insulation on lines or vessels carrying gases under pressure should be examined as an alternative to relatively costly stainless steel.

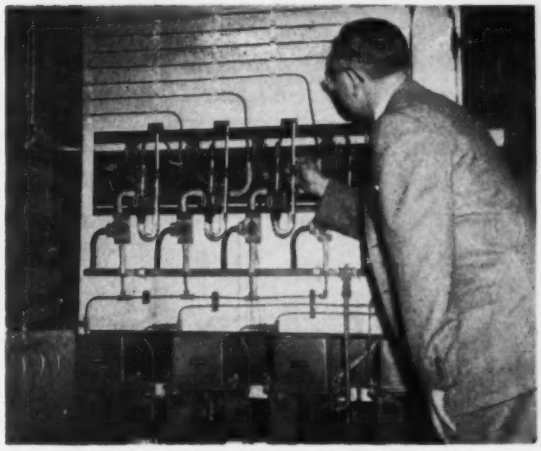
For example, using the ASME *Boiler Code for Unfired Pressure Vessels* we find that for a 20-in. OD pipe to carry 1200-F gases at 2000 psi a minimum theoretical wall thickness of 2½ in. is required when Type 316 stainless steel is used. If the temperature is raised to 1500 F required wall thickness increases to 7 in. At this temperature the 2½-in.-wall pipe would be allowable only up to 440 psi.

A word of caution: Use of internal insulation may also involve stainless-steel liners suitably supported and sealed against by-passing of hot gases. Installation is a specialized field entailing problems not ordinarily encountered when dealing with conventional insulation procedures and it is advisable to place such work in experienced hands.

Correction

Equation at bottom of middle column, p 71 last month, should read: $q = 4000/6.3 \times 635$ Btu per hr per sq ft

TEMPERATURE of condensed steam from central sample cooler is checked by author. Each sample passes through its own cooling coil



COOLED SAMPLES first run through conductivity cells mounted on wall and then enter pH flow cells below before discharging to waste

Since conductivity and pH meters are frequently mounted at point of measurement, they may be widely scattered throughout your plant. Check up on how . . .

Centralized instruments cut costs, simplify water-treatment control

By J C BOOSER, Water Chemist

Control of water treatment in the modern steam-generating plant is highly specialized and much reliance is placed on recorded data. This data must be accurate and readily available, otherwise its full value will not be realized. In many boiler plants recording meters for water-treatment control are scattered throughout the plant, often at different levels. Extended rounds must be made to collect treatment data. Locating meters at one carefully selected point avoids delay and has many other advantages that are often overlooked.

Instruments in common use for surveillance and quality control of boiler feedwater, boiler water, steam, condensate and makeup water include the following:

(1) Electrical-conductivity meters to detect condenser leakage, measure concentration of boiler-water solids, indicate and record steam quality, check evaporator performance and signal end of demineralizer runs.

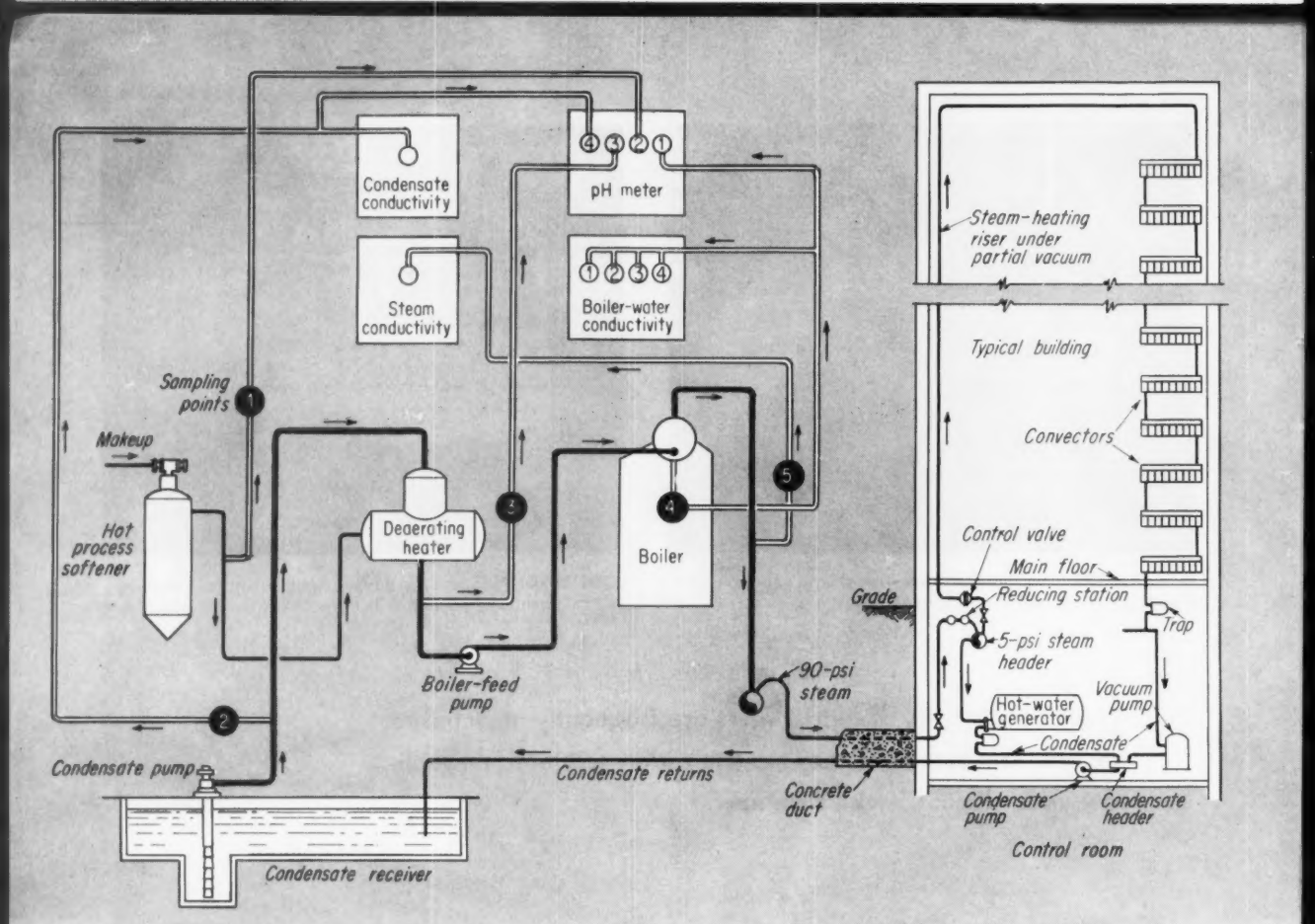
(2) Hydrogen-ion (pH) meters to check pH in the feedwater-steam-condensate cycle, control coagulation, gage length of demineralizer runs and regulate acid and caustic feeds.

(3) Dissolved-oxygen recorders to detect any oxygen contamination.

(4) Hydrogen recorders to study decomposition of steam in boilers.

Multipoint recorders are often employed with the number per boiler ranging from three to five. So in a modern utility plant with several boilers quite a few recording meters are needed for water treatment control.

Common practice is to place each meter close to the sample source. This avoids long sampling lines or lengthy electrical connections. As a result meters are scattered from the pump room to level of the upper boiler drums. For example, a multipoint conductivity recorder might be located in the pump room. Operator working at that level then has a record of condensate conductivity constantly before him to spot any condenser leakage. But the other points showing steam



CONTINUOUS SAMPLING and centralized instrumentation help operators keep central steam-heating system in topnotch condition

CENTRALIZED INSTRUMENTS continued

conductivity, vapor quality from evaporator or character of demineralized makeup will not vitally concern him.

Centralizing the water-treatment instrumentation means that one operator can scan all metered points within a few minutes. Other major advantages also accrue if these design features are incorporated in the layout:

First, bring all sample lines to one central location adjacent to the meter assembly. Sample temperature is then easily controlled without resorting to many scattered temperature-control devices. Maintenance of meters and appurtenances is greatly simplified.

Second, maintain constantly flowing samples to eliminate the time-consuming chore of collecting daily samples from widespread locations.

Central heating plant installation at a large housing development in the New York area used these ideas in an existing system to design a centralized instrument assembly for better control of water treatment.

Results over a ten-year period have been highly satisfactory. Before this improvement a full-time chemist was needed to effectively control the water-treatment program. Now plant operators are able to handle this job as part of their regular routine.

Four 100,000-lb-per-hr boilers supply steam for the heating system. Feedwater consists of 99% condensate returns and 1% makeup. A hot-process phosphate softener treats New York City municipal supply for makeup. Chemicals used for internal and supplementary treatment include sodium sulfite, caustic soda and phosphate. Aim of treatment is to prevent scale formation, corrosion and excessive carryover in the steam. And steam supply must be kept nonagressive to minimize return-line corrosion.

Four recorders make up the instrumentation for samples taken from points shown on the system sketch, above. A single-point conductivity recorder measures specific conductance of the composite condensate returns. Another recorder of the same type functions on saturated steam. A four-point conductivity recorder measures boiler-water concentrations. The four-point pH instrument records hydrogen-ion concentration of composite condensate, boiler feedwater, treated makeup and boiler water. Data from the charts of these four recorders augmented by a daily phosphate and sulfite test on each boiler are sufficient to control treatment for the entire heating system.

Design of a centralized instrumentation unit isn't difficult. First step is to select the sample-withdrawn points. Next fix location of the instrument control center. It should be in an area where the shift engineer

can readily make periodic checks of recorded data. Unit at the housing development is on the main operating floor along a wall directly opposite the main boiler-control panel.

Panel design is also important. There should be enough space both inside and outside the unit to permit easy servicing of the equipment. A cubicle is probably the best solution, although an ordinary panel with a roomy cabinet in back is a satisfactory alternate choice.

Stainless-steel tubing should be used for sampling lines leading to the instrument cubicle. Free blows just upstream from the cooling coils are also a desirable feature. Put filters in the boiler-water sample lines to remove any suspended matter. All samples can be cooled and tempered in simple tubular coils supported in a common cooling chamber.

Both coils and cooling chamber should be made of corrosion-resistant material. Ordinary steel plate uniformly coated with an epoxy resin will usually suffice for the chamber. Stainless steel presents a problem if cooling waters are saline.

Coils must have enough heat-exchange surface to reduce temperature of sample to a maximum of 90 F. Automatic temperature regulation of all samples to a common temperature, within ± 5 F, is fairly simple. Just add about 10% to the theoretical heat-exchange surface needed for each coil. Then maintain a good overflow volume of cooling water.

Samples checked for both conductivity and pH first run from the cooling coil to a flow chamber containing the conductivity cell. Then they overflow into the pH flow channel. Sample finally discharges into the waste lines through small funnels. Samples for any manual test work are drawn from these overflow lines.

Recorded data has maximum benefit when the charts are scanned at regular intervals. Watch engineer for steam system, facing page, logs minimum, maximum and estimated average values for each recorder point in service—this compels the operator to scan the records at least once or twice during his shift. Effective controls of treatment cannot be obtained if recorded data is ignored.

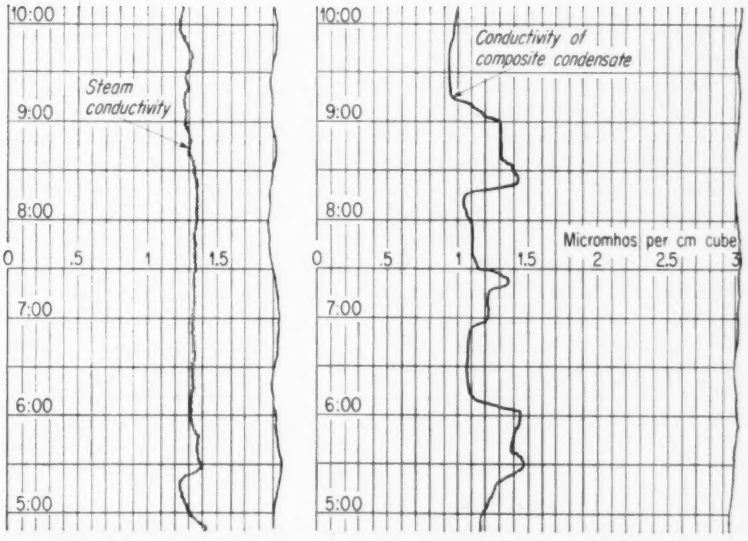
In addition the engineer responsible for water treatment frequently checks the records. At month's end all data is reviewed in detail for trends or indications of possible future troubles. Minimum coverage calls for inspection of the daily log. This eliminates need for time-consuming routine chart scanning. When unusual conditions are found in the log, the charts are always available for reference. Record checking is advisable, of course, regardless of type of instrumentation used for treatment control at your particular plant.

Benefits of centralized water-treatment instrumentation are many. They include possible savings in operating personnel as well as: (1) easier routine scanning of recorded data (2) simplified instrument maintenance (3) cooling water savings (4) dependable temperature adjustment for all samples and (5) provision for manual sampling at one location.

In two recently completed central-station units operating in the range of 1500 to 2000 psi sampling facilities are concentrated in one area. But unfortunately the instruments are located at other remote points.

Centralized water treatment instrumentation is planned for a steam-electric generating plant in the plastic industry employing steam in the range of 500 to 1000 psi. Triple-effect evaporators supply boiler-feed makeup and low-pressure steam for process. In this case instruments will monitor (1) quality of evaporated makeup and low-pressure process steam (2) concentration of solids in evaporator and boiler salines (3) quality of condensate returns from mill and acid reclaim units (4) quality of condensate from turbines (5) conductivity and pH of boiler feedwater and (6) conductivity of saturated steam.

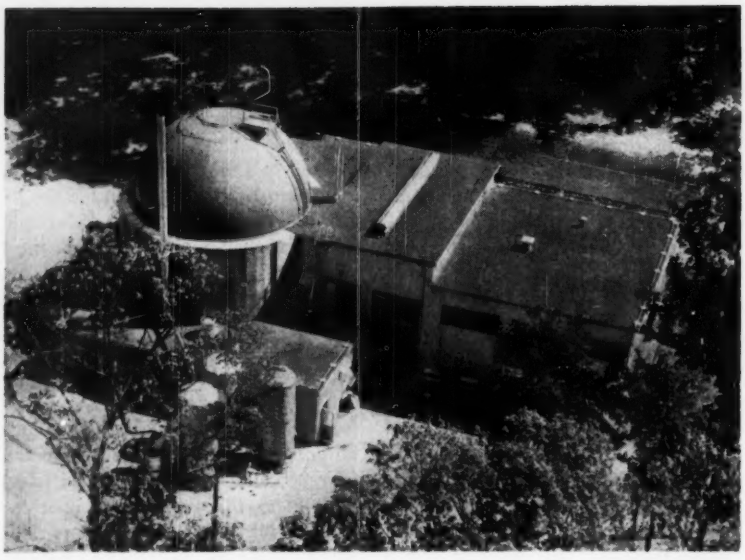
Conductivity and pH records are backbone of steam cycle control



CONDUCTIVITY of composite condensate returns for a typical month averages less than 1.4 micromhos. Steam conductivity during this period averages less than 1.14 micromhos

RECORDER shows boiler-water pH ranges from 10.3 to 11.0 with an average of 10.5

First core inspection of the APPR-1 at Fort Belvoir, Va., highlights the successful operation of this military power plant. Though the plant can't ordinarily compete commercially with conventional plants of its size, it shows that nuclear power gives special advantages in remote sites



APPR-1 AT FORT BELVOIR, VA., within 18 miles of Washington, D.C., has its 10-mwt reactor in vapor container, left. Building at right houses both offices and classrooms

Army Package Power Reactor pauses

After nearly two years of operation under variable conditions, the Army Package Power Reactor (APPR-1) at Fort Belvoir, Va., has been opened for fuel-element inspection. The 2-mwe plant first went critical on April 8, 1957 and first produced full power on April 15, 1957. Reactor has produced over 16,000 mwhre with the first core of highly enriched, over 90% U-235, uranium. The core had been designed to produce 15 mwyrt for a total burnup of about 40%.

Table, p 90, lists the essential data for APPR-1 and its first army-outpost descendant, APPR-1a, being built at Fort Greely, Alaska.

Plant operation. Besides demonstrating the feasibility of small pressurized-water reactor plants, APPR-1 gives opportunity for research and development in a full-sized working laboratory, and most importantly serves as the training base for future armed-services operators of military nuclear plants.

In its use as a training instrument the plant has been shut down and started over 350 times—much more frequently than a plant in ordinary service. This experience has amply shown that the plant can be fully loaded in 70 seconds from hot zero load.

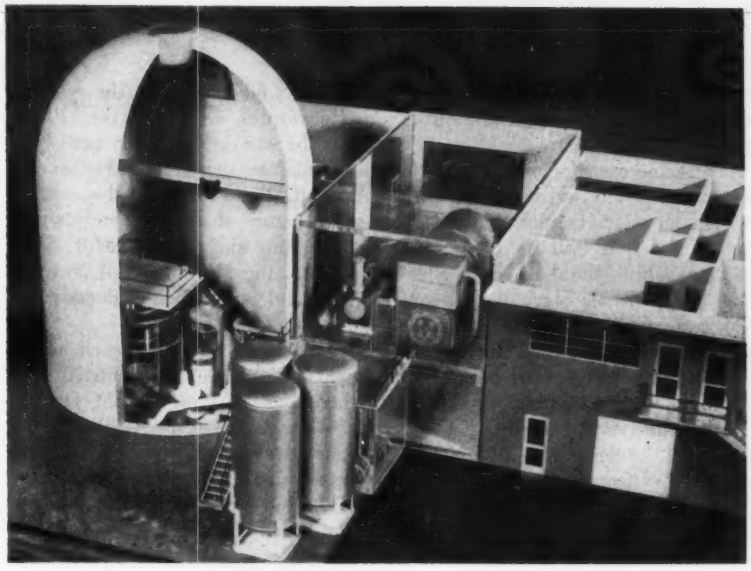
Once the reactor control rods have been adjusted to hold criticality in the core they are not touched to vary heat output except to compensate for burnup. Graphs, facing page, show one dramatic test of reactor stability. Five times within 1¼ hours the main circuit breakers were tripped to reduce full load on the turbine to just the station auxiliary load. Unit was resynchronized to the load each time after waiting to see that reactor output remained stable. During this demonstration reactor controls were never touched.

Running the plant as a sole source of power for a load, as it might be on a remote military base, raises a problem. Adding load increments in excess of about 35% of capacity drops plant frequency enough to cause instruments to signal a spurious scram. Studies and tests now under way seek to correct this condition and also assure that swelling of water in the steam generator will not carry over into the turbine.

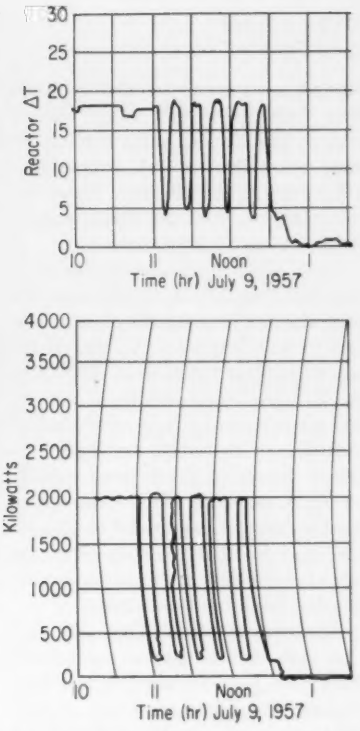
During normal operation opening and closing the turbine steam-control valve reflects back through the steam generator and primary loop to make reactor automatically vary its heat output with turbine demand. Negative temperature coefficient of the core exerts automatic control of chain reaction to the extent that on emergency loss of load reactor drives itself subcritical without scramming. This allows it to resume heat production as soon as turbine can be reloaded.

Average of primary-water inlet and outlet temperatures at the reactor stays constant at all loads once core is hot.

Testing. During the initial series of tests in 1957 the steam generator failed to deliver superheated steam.



VAPOR CONTAINER OF APPR-1 holds reactor, left, steam generator, two circulating pumps, pressurizer behind reactor. Feedwater heater, evaporator stand next to turbine



FIVE MAIN BREAKER TRIPS in 1¼ hours on main generator feeders show reactor's ability to drop main load and again pick it up without adjusting the control rods

for its first inspection

Excessive pressure drop across the separator drew water up the drain line into the dry side. Separator was replaced with another type during a three-week shutdown.

Acceptance test specified by the army required plant to run at 10 to 100% capacity for 700 hr continuously with maximum allowable forced shutdown time of 40 hr. The test actually had only 7 hr, 28 min of shutdown. Electrical disturbances in the fort's distribution system scrammed the reactor three times. Calibration of the liquid level in the shell side of the steam generator needed a fourth shutdown.

Six-month test following the acceptance test ran the plant at full capacity each month for 21 days and then at varying loads to train personnel. During this test the primary-system rupture disk, which was being used with the center cut out) as a gasket beneath the flange of the spacer piping to the relief valve, leaked a small amount of primary coolant for many weeks and deposited radioactive matter on the vapor-container floor. Leakage eventually grew to a rate that had to be stopped.

A relief valve replaced rupture disk and a welded connection replaced the flanged connection. Simply swabbing and hosing down lower wall and floor cleaned up the radioactivity.

After this incident, a spring failure in the pressure-relief valve again leaked primary coolant. But repair and cleanup by flushing were done in short time without trouble.

Pump performance. Various pumps caused trouble, with the exception of the primary-loop canned-motor pumps. The stainless-steel plungers on the makeup pumps wore excessively causing leakage through the packing. Hastelloy and ceramic plungers replaced the original ones and so far have worked very satisfactorily.

Heating and cooling. It took 30 hr to cool the primary loop from 450 to 212 F, after shutdowns. The pressurizer, being a well-insulated dead leg in the primary loop, had very slow circulation and so took a long time to cool. A separate line recently installed from the primary piping to the top of the pressurizer should cut cooldown time to about 12 hr by forcing water circulation through the unit.

For normal load-carrying operation the pressurizer has electric heating coils to control the primary-loop pressure. When pressure rises above normal the heaters are shut off and normal heat radiation through the pressurizer walls allows some of the pressurizing steam to condense and lower the pressure. No water sprays are used in the pressurizer.

During shutdown the radioactive fuel elements in the core generate heat that must be removed. Circulating primary water through the core keeps it at 220 F when idle. Steam generator acts as a water-to-water heat exchanger to cool the primary loop.

The two paralleled primary-coolant pumps discharge into a Y check valve

that allows a small circulating backflow through the idle pump. Heavy ribs of this special valve cannot tolerate more than a 45-F temperature differential. This feature limits the rate of temperature rise during startup from cold to 30 F per hr.

At a 450-F operating temperature and 220-F shutdown temperature the total starting time for the plant is limited to 450–220/30 = 7.7 hr. If the second coolant pump were eliminated the Y valve would also be eliminated and shorten startup time considerably.

Radioactivity within the vapor container decays to a safe level quickly on load removal. The water-sealed double door can be opened in 12 minutes and by that time operator can enter immediately after routine health-physics check has been made.

Instrumentation. Over 300 electron tubes in the reactor control circuits have been replaced in less than a year. Amplifiers must run at high gain to raise the weak signal strength of the ion chambers.

The replaced tubes could work satisfactorily in conventional electronic circuits, but when they develop a high noise level they cannot be used in the reactor control circuits. Noise and transients cause many false-period scrams. New type ion chambers with improved connectors, use of filters and correction of improper sealing of mineral-insulated wire terminals has partly mitigated the problem. Additional development work is in progress on the chambers and co-axial cables subjected to radiation damage. Transistors are being evaluated as a possible solution.

High flux during normal power operations made the original BF_3 counter tubes fail. These were replaced with another make. High internal noise level caused by residual radioactivity made it necessary to replace several fission chambers.

Water purity in the secondary system poses a problem. The type 304 stainless-steel tubes in the steam generator cannot be inspected and they are highly susceptible to chloride stress corrosion. Recording conductivity cells in the evaporator and secondary-system blowdown water monitor the chloride concentration backed up by daily laboratory analysis. Chloride content has been held to 0.1 ppm by using a blowdown rate of 0.2 to 0.5 gpm.

Hydrazine used for oxygen control is not completely effective as shown by the air ejectors maintaining the oxygen level at 0.01 to 0.04 ppm. Sodium sulfite would be more effective and desirable since it does not add ammonia to the system, but it prevents monitoring the chloride concentration by conductivity because of the solids formed by the NA_2SO_3.

Radioactivity buildup. Long-lived nuclides tend to build up on the primary - system surfaces. Buildup could reach magnitudes that would seriously hamper work on primary-system components. Activity on primary side of steam-generator tube sheet is about 2.5 roentgens per hr. Main nuclides contributing to the activity include: Co-60, Co-58, Fe-59, Mn-54 and Cr-51.

Second core of APPR-1 will have a special low-cobalt stainless-steel type 304 cladding. This may reduce the rate of Co-60 buildup in the system.

Personnel. Ordinarily the APPR-1 can be run by two men per shift plus a maintenance crew and supervisory staff. But because of the experimental nature of the plant and its use as a training aid, the contractor, Alco Products, Inc, has a staff of 25 men to run and maintain it and assist in training.

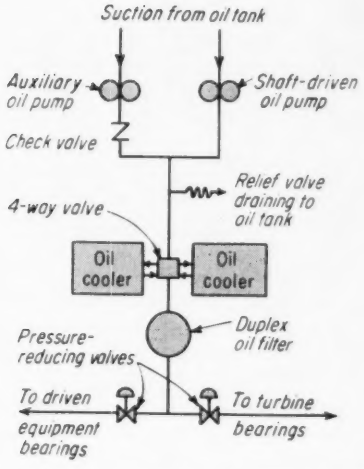
Two classes a year, each comprised of 50 men, are trained in the Army Nuclear Power Plant Operators' Course held at the APPR-1. The Special Assistant to the Chief of Engineers for Nuclear Power administers the school. Trainees are selected from Army, Navy and Air Force enlisted personnel.

POWER gratefully acknowledges the assistance of the following men in supplying data for this article: Col D G Williams, Assistant Director (Army Reactors) Division of Reactor Development; and Messrs K Kasschau, H L Weinberg and J K Leslie, all of Alco Products, Inc.

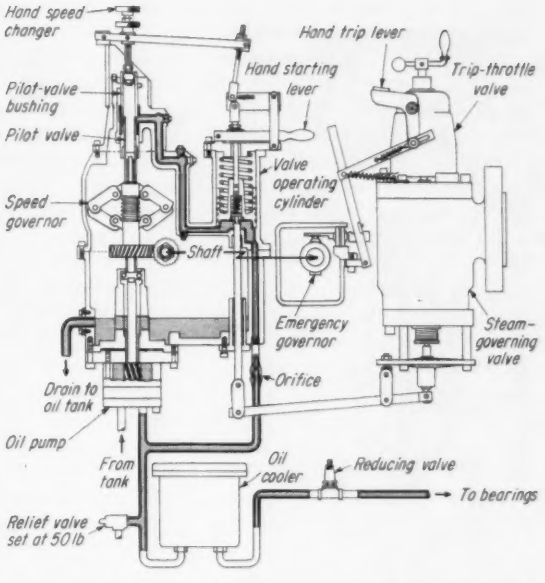
Army Package Power Reactor costs

Plant	APPR-1	APPR-1a
Location	Fort Belvoir, Va.	Fort Greely, Alaska
Owner	AEC; Corps of Engrs	Corps of Engineers
Reactor type	Pressurized water	Pressurized water
Primary pressure, psig	1185	1185
Steam pressure, psig	185 full load, 407 no load	185 full load, 407 no load
Output		
Thermal, kwt	10,000	20,000
Electrical, kwe net	1925	1640
Heat, Btu per hr	—	38,275,200
Costs		
Research & development	$2,000,000	$100,000
Design	358,500	371,642
Construction	3,458,360	4,737,217[a]
Fuel elements	110,701	160,000
Test operation	350,000	—[a]
Total	6,277,561	5,368,859
Constructor	Stone & Webster Engineering Corp	Peter Kiewit Sons Co
Fuel-element supplier	Oak Ridge National Laboratory[b]	Sylvania-Corning Nuclear Corp
Turbine-generator builder	General Electric Company	General Electric Company
Initial operation	April 1957	Early 1960
Reactor-system builder	Alco Products, Inc	Alco Products, Inc

[a]—Contract includes four months of test operation
[b]—Second core supplied by Sylvania-Corning Nuclear Corp



1 Turbine lubricating-oil system uses a variety of pumps to feed the bearings



2 Turbine lubricating-oil system also supplies hydraulic force needed to move the governor system and steam-control valves

When any part of a system can be made to do several duties, the system becomes more compact and less costly. This principle is put to good use in . . .

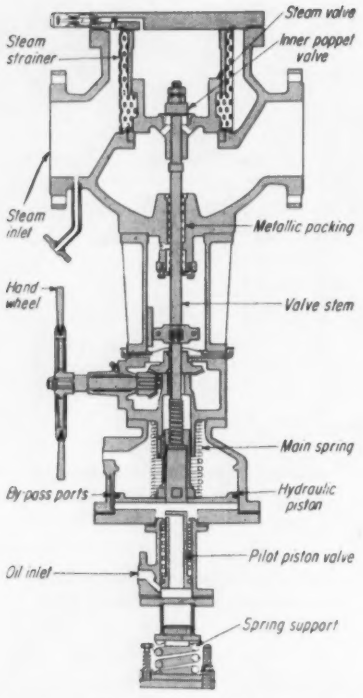
M-d turbine lubricating-oil systems

By E J PHILLIPS, Product Design Engineer, Small Steam Turbine Department, General Electric Company

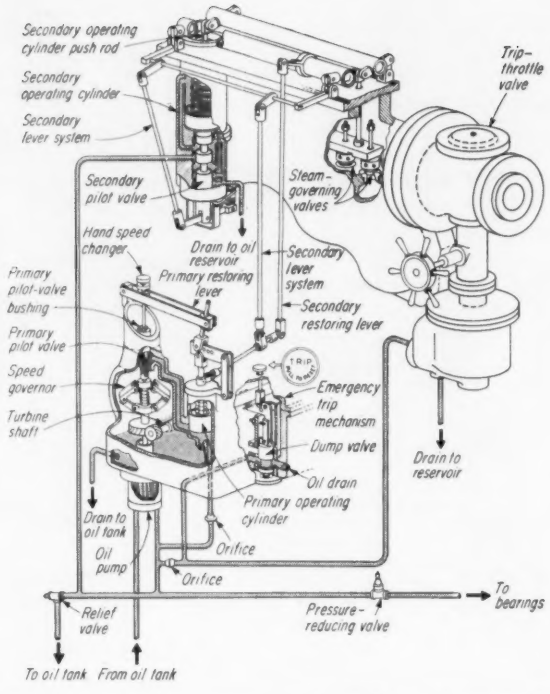
Turbine oil systems vary widely with type of application and the governing industrial code. We'll only be able to talk about a "typical" system. Turbine oil systems circulate lubricating oil in a closed cycle to: (1) lubricate moving parts, Fig. 1, (2) carry away heat radiated from hot turbine parts to the bearings and developed by friction between moving parts (3) provide power to move steam-control valves in response to speed-governor signals.

Oil selection. The table on p 93 shows some typical oil characteristics for turbine sets. Manufacturer's recommendations for oil selection should be followed closely; a poor oil can cause serious damage. A good turbine oil should: (1) be noncorrosive to turbine and oil-system parts (2) inhibit rusting of turbine and oil-system parts (3) free itself rapidly from entrained air and water (4) resist foaming and (5) resist sludging and oxidation.

Piping. Oil-system design must account for the fire hazard created by the turbine steam temperature. A fine mist of turbine oil exposed to a hot surface of about 500 F may ignite even in the absence of flame. To reduce leakage and breakage at threaded joints, welded and flanged seamless-



3 Trip-throttle valve depends on an oil-pressure change to work automatically



4 Multivalve turbine governor system uses secondary operating cylinder that works from force supplied by turbine oil system

steel schedule 40 or 80 pipe is used on exposed oil lines whenever possible. This includes pressure and drain piping.

"Guarded piping" may be used where an oil leak would be very dangerous. In this design the pressure piping runs inside the larger drain pipe. A leak in the pressure pipe simply drains back to the oil tank.

Some oil-system components do not have flanged connections and a threaded joint can't be avoided. For these a short straight extra-heavy nipple is used with a welded flange as close as possible to the joint. Threaded fittings may be used inside an oil tank or in guarded locations where leakage raises no fire hazards. Schedule 80 pipe is used here. Fig. 1 outlines a lubricating system for an m-d turbine.

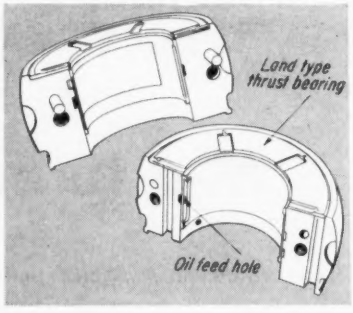
Oil tank. A well-designed oil tank aids deaeration of the oil to avoid cavitation in the oil system. Oil falling freely through air will absorb some of it as the oil falls and splashes. This air must be removed before oil enters the pump suction.

Most common way to deaerate oil discharges it horizontally into the tank with pipe center line at about a level with oil surface. This minimizes air entrainment and allows foam in the pipe to flow out on the oil surface and avoid mixing with oil going to pump suction. Drain piping should be sized to limit flow rate to 1 ft per sec. A higher velocity agitates, aerates the oil.

Another method discharges the oil horizontally into the tank several inches above oil level, and across a sloping baffle that extends below the oil level. The oil spreads out on the baffle and deaerates. Sometimes vertical baffles direct aerated oil away from the suction.

The oil tank must be vented to aid deaeration. Not less than 0.15 sq ft of oil surface per gpm oil flow is recommended for the tank to get adequate deaeration. Oil tank capacity should not be less than three times the discharge flow per minute from main oil pump.

Oil pumps may be of positive displacement or centrifugal types. The drive and arrangement may be: (1) geared from or directly coupled to main turbine shaft (2) mounted on and driven by gear set between turbine and driven equipment (3) auxiliary turbine (4) electric motor.



5 Journal and thrust bearings use oil for lubrication and removing the heat

In conjunction with (1) and (2) an auxiliary electric, steam or hand-operated oil pump may be needed for starting the turbine. Oil pump must supply oil over the entire speed range including the low speeds during turbine shutdown operation.

Turbines with a wide operating speed range cannot advantageously use pumps as in (1) and (2). At higher speeds a large part of the oil flows directly back to the tank through the pressure-relief valve. This reduces the overall efficiency of the turbine

by absorbing the excess horsepower.

When an oil system uses both an auxiliary-turbine-driven and an electric-driven pump an accumulator must often be added. The latter maintains oil pressure during the interval when motor-driven pump stops on electric failure until the turbine-driven pump comes up to pressure.

Pressure-relief valve protects against overloading the pump and controls oil pressure to the governing system. Positive-displacement pumps need this protection since discharge flow rises with speed at a greater rate than the oil system needs. If pump discharge pressure overloads the pump driver some component will fail. Excessive discharge pressure could cause the impellers of a gear type pump to spread, rub the casing and seize. The relief valve should be able to pass the full pump flow.

Oil coolers usually have fresh water flowing through the tubes, oil through the shell around the tubes. The cooler removes both frictional heat and heat absorbed from hot turbine parts.

Excessive oil cooling may precipitate scale on the tubes from impurities in the coolant. Too cool an oil reduces evaporation of water that collects in the tank and may increase condensation foaming inside the tank. When oil coolers are installed in duplicate either one can be taken out of service without shutting down the turbine. A four-way valve allows a changeover without halting oil flow.

Filter removes minute particles from the oil system. Usually the filter must trap particles about 0.001 in. in diameter as a minimum. Filter should be in a pressure line after the relief valve; if it were before the valve plugging would make valve ineffective for pump overload protection. Placing filter on the pump-pressure side of a bearing pressure-control valve will not affect oil flow if filter should partly clog, providing the pressure remains higher than valve's pressure setting.

Control valves reduce the oil pressure to that needed by bearings. They maintain a constant pressure regardless of oil flow that varies with speed and normal bearing wear. Sometimes driven equipment needs oil at a pressure different from turbine bearings. A second control valve will then be needed, see Fig. 1, page 91.

Oil-system design affects turbine components like trip-throttle valve, pressure switches, alarms, bearings and control system, even though they are not part of the oil system.

Trip-throttle valve, Fig. 3, shuts off steam flow if the turbine overspeeds or reaches some other limit. Fig. 4 shows how oil flows to the emergency governor-trip mechanism and to the piston connected to the trip-throttle valve. In the tripped position shown, oil dumps back into the tank.

Resetting mechanism repositions dump valve to close the drain port. Oil pressure then builds up beneath the trip-throttle valve hydraulic piston and allows valve to be opened.

Journal bearings must be free from wear to maintain shaft position and proper internal turbine clearances. Oil enters the bearings through passages in the housing and bearing shells to flow into axial grooves and chamfers at the horizontal split. Grooves distribute the oil along the length of the bearing and chamfers help form wedges of oil between journal and bearing. Rotating journal floats on the oil wedge to prevent contact between journal and bearing.

Oil flow in excess of that needed for lubrication carries away heat from the turbine. Heat is conducted through the shaft and casing.

Thrust bearing, Fig. 5, transmits the axial shaft thrust to the turbine frame. Though thrust normally acts in the direction of steam flow, two babbitted thrust bearings are used to prevent axial movement of the rotor in either direction.

Radial grooves divide the bearing surface of the land type bearing into a number of sectors. In tapered-land bearings the contour of each sector surface assures formation of an oil wedge. Oil entering at the inner edge of the bearing spreads over the rotating thrust runner with the aid of centrifugal force. Oil flows to the thrust bearing through passages in the journal bearing housing.

Control system of a turbine, Fig. 2, takes its oil through an orifice to flow to the spring-loaded piston in the valve-operating cylinder and to the speed-governor pilot valve. Varying oil pressure opposes the spring-loaded piston to open and close the steam valves. For more operating detail see Part 5, POWER, May 1959, pp 68-70.

Typical oil conditions for turbine sets with forced-feed lubrication

Physical properties	Direct-connected sets	Auxiliary geared sets
Saybolt viscosity, ssu		
at 100 F	140-170	270-325
at 210 F, approx	43-45	47-60
Flash point, F minimum	330	350
Neutralization value		
mg KOH/g—maximum	0.20	0.20
Rust-prevention test	shall pass	shall pass
Oxidation test, hr	1000	1000
Oil temperatures		
Maximum viscosity before starting, ssu	800	800
Minimum oil temperature before starting, F	50	70
Minimum operating oil-tank temperature, F	130	130
Operating bearing-inlet oil temperature, F	110-120	110-120
Satisfactory bearing-outlet oil temperature	140-160	140-160

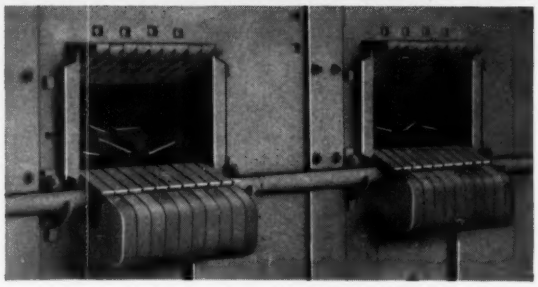
Note: For any specific turbine set use manufacturer's recommendations

For Fuel Firing Versatility ...Low Cost Maintenance ...High Operating Efficiency

INSTALL

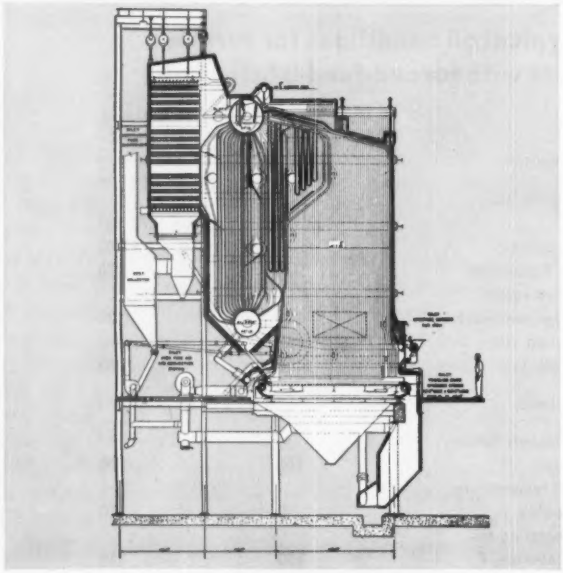
Riley Traveling Grate Spreader Stokers efficiently burn coals having a wide range of coking, caking, and ash fusion characteristics. High working efficiencies are produced with low grade fuels such a sub-bituminous coals, lignite, wood refuse, bagasse, and other cellulose materials.

B. F. Goodrich, Champion Paper and Fibre Co., E. I. Dupont de Nemours, General Electric, Montana-Dakota Utilities, Gaylord Container, Utah-Idaho Sugar, Kennecott Copper, Swift & Co., Bendix Aviation, Armstrong Cork are but a few of many prominent companies that are using Riley Spreader Stokers under Riley Boilers. Such performance-proven installations as these substantiate the superior operating characteristics of Riley Spreader Stokers: uniformity of feed and distribution . . . complete, continuous combustion . . . low carbon loss . . . high day-to-day overall efficiency . . . long-term, low-cost maintenance.



Two Feeder Models

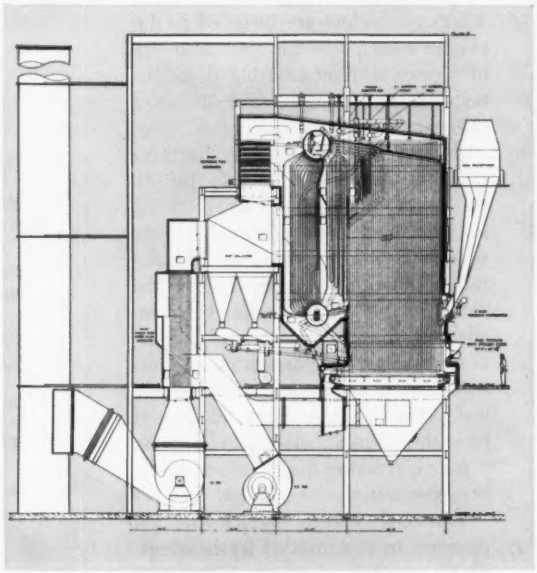
Riley Spreader Stoker Model 'B' Feeders are supplied for capacities up to 200,000 lbs/hr; Model 'D' Feeders for boiler capacities over 200,000 lbs/hr have feeder drum in coal hopper which meters coal regardless of moisture. Adjustable distributor blades give uniform coal distribution.



In Combination With Natural Gas Firing

Deere & Company, Moline, Ill.

20' x 16' Riley Traveling Grate Stokers equipped with Riley Model 'B' Feeders fire two complete Riley Steam Generating Units with pressurized furnaces. Riley Intertube Gas Burners fire natural gas as an auxiliary fuel. Capacity 135,000 lbs/hr, 750F, 650 psig. Efficiency 84.8%.



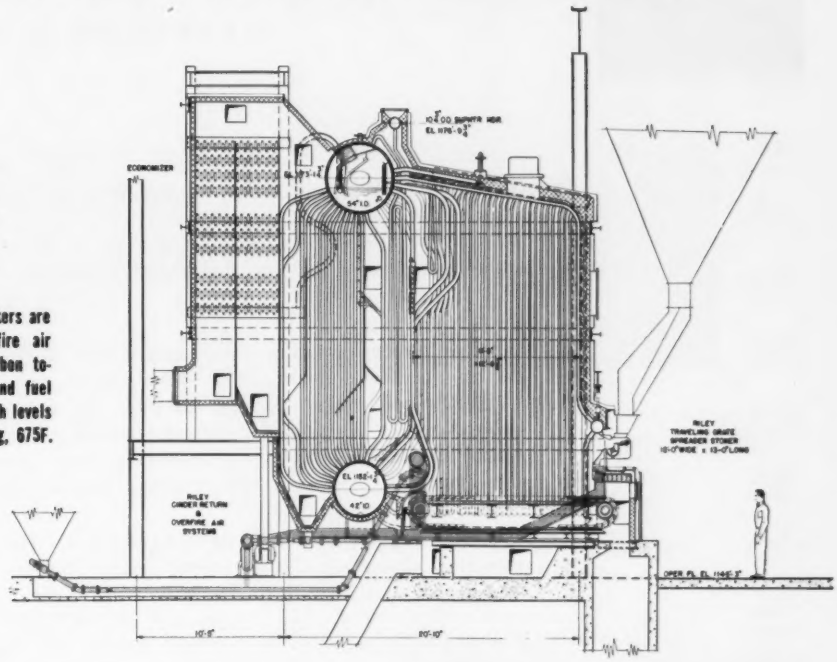
Simultaneous Bark and Coal Firing

Marathon Southern Corp., Naheola, Alabama

A 26' x 22' Riley Traveling Grate Spreader Stoker, fed by Riley Model 'D' heavy-duty Coal Feeders and Riley Pneumatic Bark Distributors, fires this 300,000 lb/hr Riley Steam Generating Unit with an efficiency of 85%. 975 psig, 825F.

RILEY SPREADER STOKERS

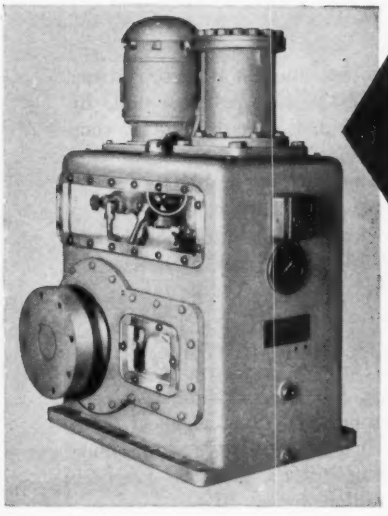
With Either Traveling, Oscillating, Dumping or Stationary Grates



Cinder Return And Overfire Air System

Pennsylvania Railroad, Juniata Shops, Altoona, Pa.

Many Riley Traveling Grate Spreader Stokers are equipped with cinder return and overfire air systems. High recovery of unburned carbon together with intimate blending of air and fuel assures a wide range of operation at high levels of efficiency, 3 — 60,000 lb/hr, 600 psig, 675F.



Smooth, Continuous Operating Hydraulic Drive for Traveling Grates

The self-lubricated Riley Hydraulic Traveling Grate Drive power unit operates quietly and smoothly with uninterrupted continuous automatic or manual speed control from stop to full load. The design does away with sprockets, chains or gears. A pressure gauge describes load conditions at all times.

High Efficiency Grate Surface

Providing high efficiency with low maintenance requirements, the surface of the Riley Traveling Grate Spreader Stoker has small (2" x 6") overlapping grate clips, of special heat-resisting alloy. Nose-over-tail design forces clips to separate when starting return travel, freeing themselves of ashes and clinkers. Tuyeres in the center and at sides of clips give uniform air distribution.

A careful survey of your plant by a qualified consulting engineer could show ways of making substantial savings in power costs.

RILEY

STEAM GENERATING & FUEL BURNING EQUIPMENT

Call a Riley Sales Engineer for experienced technical advice covering your requirements for both boiler and fuel burning equipment.

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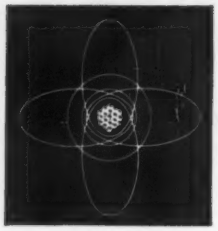


Nuclear notes

By B G A SKROTZKI, Associate Editor

Vallecitos Boiling Water Reactor has produced superheated steam in an in-pile demonstration loop in its core. General Electric Co reports that uranium-oxide ceramic fuel elements supplied the superheating energy; no specific data was announced. In the same area Argonne National Laboratory is working on a design study for a 15-mwe boiling-nuclear-superheat (BONUS) electric plant for AEC.

Eight nuclear firms have offered proposals to AEC to study and develop reactors for producing superheated steam. These include developing fuel materials, methods of steam separation and evaluating heat transfer. The firms include: Advanced Technology Laboratories, a Division of American-Standard; Atomics International; Battelle Memorial Institute; Combustion Engineering, Inc; General Electric Company; Nuclear Development Corp of America; Nuclear Metals, Inc; Westinghouse Electric Corp.

Process-steam reactor developed by H K Ferguson Co and The Martin Co is expected to produce 150-psig steam at an overall cost of 70 cents per million Btu, when run at an annual plant factor of 91%. The pressurized-water reactor uses an 890-psig primary loop with a reactor outlet temperature of 430 F and an inlet temperature of 376 F. Two parallel heat exchangers produce 150,000 lb steam per hr. The reactor has an aluminum-clad uranium-oxide core good for one year's operation at full load. Total investment will run about $2.5 million.

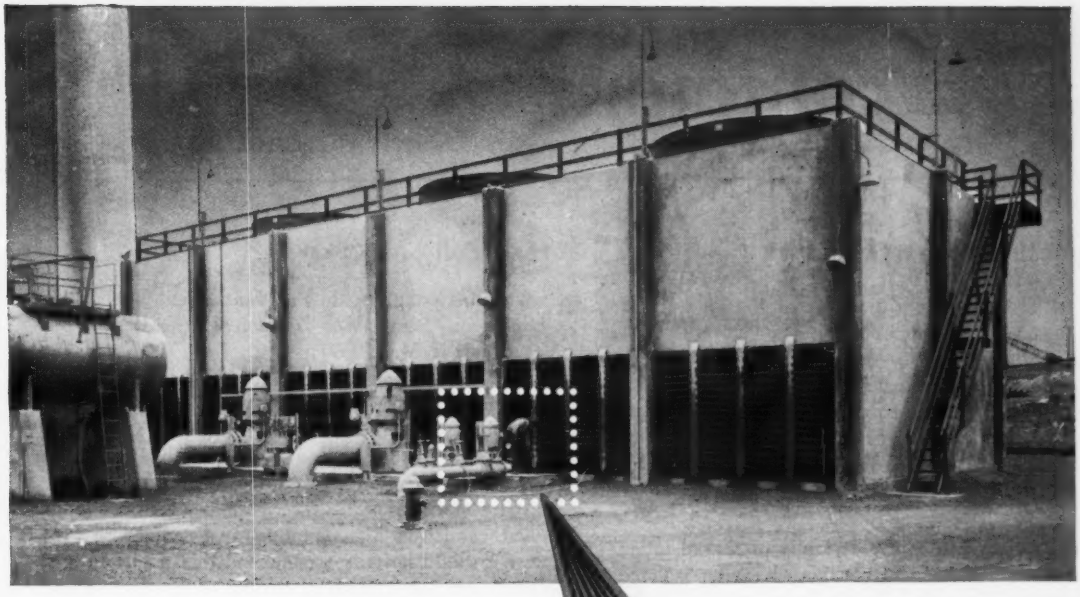
Boiling heavy-water reactor (HBWR) will soon go into operation at Halden, Norway. The 20-mwt reactor, built inside a mountain, will supply steam to a paper mill. Reactor was designed by Norway's Institutt for Atomenergi and is being built in cooperation with Norwegian industrial groups. Two Argonne National Laboratory engineers are aiding the Institutt in starting and testing the reactor.

Joint meetings will be held by the American Nuclear Society and the Atomic Industrial Forum during the falls of: 1959 in Washington, D.C., 1960 in San Francisco and 1961 in New York City. This will help avoid excess travel. Both organizations will hold additional individual meetings through the year.

Savings with radioisotopes are being studied by the National Industrial Conference Board for the AEC; the final report will be made by June 30. Preliminary report shows the petroleum industry benefits most, followed closely by the chemical industries. One paper company saves over $193,000 yearly with beta gages at an annual cost of about $10,000. One pressure-vessel manufacturer saves $100,000 yearly in radiography work. All industry saved about $330 million during 1956.

After 18-month run the turbine of the General Electric Company Vallecitos boiling-water reactor plant did not retain enough radioactivity to hamper maintenance work. No corrosion-product deposition built up on the heat-transfer surfaces of the core that started on Oct 27, 1958. Plant uses demineralization flows of more than 50 gpm per sq ft of resin bed for condensate returning to the reactor.

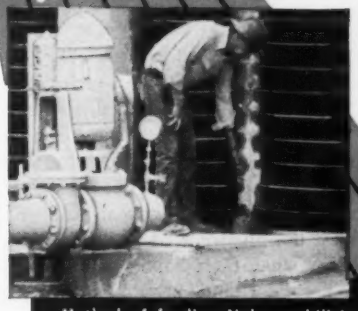
Latest Army nuclear power reactor (SM-2) under design will produce a minimum of six mwe. Alco Products, Inc has been working on the design for nine months; plant will power remote-area military installations, including missile stations. Alco's contract, AEC and Army Corps of Engineers will cost almost $2 million.



Unusual Cooling Tower

gets proven *Nalco* protection

This unusual cooling tower was built for the Riverside Cement Company at Oro Grande, California. The advanced design provides for concrete exterior walls which support and enclose fan units and redwood interior cooling vanes . . . The entire "working sections" of the tower can be repaired or replaced without affecting the structural strength of the shell. Nalco System Treatment protects this cooling system against scale and corrosion — has protected it effectively since it was first put in operation over two years ago. You can get the same complete water treatment protection, promptly, from Nalco. Write for details.



Method of feeding Nalco stabilizing treatment to this system is simplicity itself. Formula is supplied in ball form. Once each shift a perforated tube suspended in the tower basin is filled with balls which slowly dissolve in the cooling water.

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THE *Nalco*® SYSTEM ... SERVING INDUSTRY THROUGH PRACTICAL APPLIED SCIENCE

Nalco CHEMICALS

For more facts circle 248 on Reader Service card, p 125

Reserved for your comment

BOB BELLAS, Associate Editor

Pride goeth before a fall-apart

As we all know, due to the laws of physics we have yet to construct a machine of 100% efficiency. However, with modern technology we are constantly improving efficiency rates as we strive for perfection. With this trend in mind I, as I'm sure many other readers do also, commend your staff for the highly efficient "new look" of POWER.

DAVID STUART, *Newark, N. J.*

. . . For six years I have carefully preserved intact my issues of POWER. I considered saving isolated articles, tried it, and found that system wanting. After additional experimentation, I decided that the only reasonable approach to the problem was to unstaple the magazine, remove the advertising (what little can be removed without carrying away some part of a feature article) and bind the remainder in a permanent file. With this system I have a well-indexed collection of one year's issues in a good binder, yet I can remove a page for photocopying.

As with all good things I'm afraid that the end has come. The March issue arrived and I proceeded to process it as outlined above. It didn't take long before I had an assemblage of pages that were tearing at the perforation line which lies outside the binder's clamping action.

I can visualize only too vividly what my library of POWER will look like from here on out. Frankly, I'd just as soon receive a collection of loose pages, unstapled, unglued and unperforated. In fact, I'd be willing to pay extra for this service. I'm sure it would be less than the cost of the tape that I use to hold the pages together.

I appreciate that this is an unusual problem. But I wonder what the hundreds of librarians who file POWER will say when their bound volumes start to come apart. I wonder how long POWER will remain on library shelves when this occurs?

I wish that I could share in your glow of pride at this innovation, but for me it would be better off as a stillborn idea in some editor's mind. If it's possible to obtain an unperforated issue, please place my name on that list.

C W MATTHEWS, *Denver, Colo.*

EDITOR'S NOTE: *We appreciate this problem faced by many librarians in preserving copies of* POWER *in the perforated state.*

For the vast majority of our readers the perforated page simplifies the job of filing tear sheets. We took this step only after considerable research into readers' filing habits. But we are investigating making unperforated copies available. When we have definite information, we'll spread the word.

Curtain call

We must congratulate Bob Marks and POWER for the special report, *Water treatment* (Part I, Dec 1958 and Part II, Mar 1959).

In our opinion this report is a splendid coverage of the subject with generous inclusion of the latest technology. Scope and importance of water and basic water chemistry are well handled. Ground rules and direction of water-treatment processes are well established. This is accomplished in a simplified, condensed and well-illustrated manner.

We would heartily recommend this report to any party interested in an up-to-date review or to those desirous of obtaining a general knowledge of industrial water treatment.

T L MOORE and V T BURNS, *Gibbs & Hill, Inc*

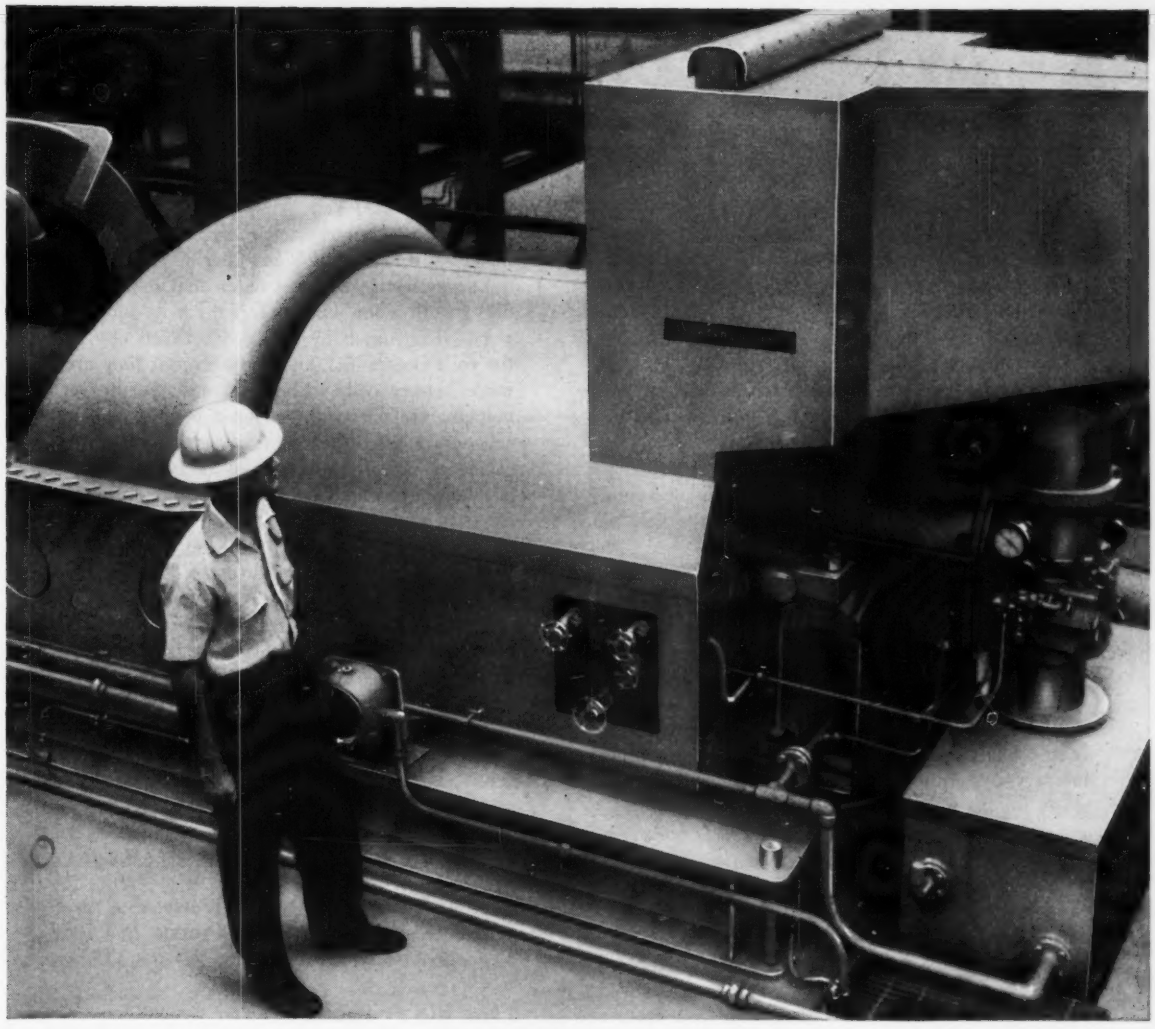
It's lightup time

I read Mr Peach's excellent report with great interest (*Engineered lighting moves ahead*, May, p 51). As usual, POWER did a great job of condensing voluminous technical reports for the busy reader. But, as your author says, "Interest in quality today is emphasized by the growing importance of consulting engineers who specialize in lighting." For such engineers, it is well worthwhile to study Dr Blackwell's original report to the Illuminating Engineering Research Institute.

Like all research projects, the investigation of visual requirements depends on sufficient interest to get someone to appropriate enough money to undertake it. To me the remarkable aspect of work being done by Dr Blackwell and his associates is why this has not been done before. I am aware, of course, of other work done in the field, notably by Dr Sylvester K Guth and Arthur A Eastman, much of which is reported in monographs reprinted by the American Journal of Optometry Publishing Ass'n (Forshay Tower, Minneapolis 2, Minn.) Dr Blackwell's report can be obtained from the IERI, 1860 Broadway, New York 23, N. Y.

There are many parts of the Blackwell report which appear to be concepts for specialists, and Peach was wise in not trying to explain them in detail. However, a lighting engineer should equip himself with such concepts as *visual capacity* and *suprathreshold visibility factors*. Dr Blackwell explains them at length. Unfortunately, he doesn't do as thorough a job explaining the *visual task evaluator* which is probably his (and his associates') most unique contribution in the visual-research project. I haven't read a description of this device that satisfies me. This is important since the device relates theoretical research to practical in-plant seeing tasks.

continued



Westinghouse multi-stage, hi-speed turbines guarantee you

...engineered power to meet your exact needs

Why pay for power you can't use? Or, by the same token, why strain a machine beyond its capability? Westinghouse can meet your exact turbine requirements with the world's broadest line of wheel sizes and design capabilities for steam conditions through 2400 psig—1050° F at the throttle, exhausting from 1 in.hg absolute to 300 psig.*

Fitting the right wheel size to the job is the key to efficiency and economy. By knowing your process requirements, cost of steam and number of hours you expect your turbine to run during the "payoff" period, we can provide the turbine design best suited to your power and economic requirements.

To meet these varied requirements, Westinghouse has available five frame sizes of multi-stage, hi-speed turbines with wheel diameters ranging from 12 in. to 32 in. In addition, interchangeability of many wearing parts saves you money on inventories and stocking of spare parts.

Westinghouse turbine specialists located throughout the country are available at all times to provide personal attention to your heat balance problems, and are equipped to offer on-the-spot price and performance data for this entire turbine line. The capabilities of the world's largest and most modern small turbine facility are at your disposal. Call your Westinghouse representative, or write Westinghouse Electric Corporation, Small Turbine Sales, Lester Branch Post Office, Philadelphia 13, Pennsylvania. J-50605

***WESTINGHOUSE MULTI-STAGE, MULTI-VALVE, HI-SPEED TURBINE FRAME CAPABILITIES**

Turbine Frame Number of Stages	M-12	M-16	M-20	M-25	M-32
			As Required		
Wheel Size, in.	12½	16	20	25	32
Maximum hp	4000	5000	7000	10,000	16,000
Maximum rpm	16,000	12,500	10,000	8000	6000
Maximum P_1, psig	1500	1500	1500	1500	1500
Maximum T_1, °F/T	950	950	950	950	950
Maximum P_2, psig	300	300	300	300	50
Exhaust Size, in.	20	24	30	36	48
D. F. Exh. Size, in.	30	36	48	42 x 64½	48 x 84
Max. Inlet Size, in.	5	6	8	10	12

(For special applications, inlet steam conditions to 2400 psig, 1050° F total temperature can be accommodated.)

YOU CAN BE SURE...IF IT'S

Westinghouse

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV MONDAYS

As you can see, I'm an enthusiast for good lighting, and I think plant engineers, contractors and architects should educate themselves on the subject of what is required to *see*—that is, to do an efficient job without ruining one's eyes. Reports like POWER's and the Illuminating Engineering Society's publications all help, but judging by lighting levels in plants I visit, we are only scratching the surface.

EMIL WAGNER, *Minneapolis, Minn.*

. . . I was thoroughly impressed with the information contained in the report. It has stimulated some thinking on my part toward improving the lighting level in my own plant.

If I had a three-phase four-wire 440-v distribution system I could readily adopt a 277-v lighting scheme using high-output lamps. Unfortunately I must restrict myself to attaining higher lighting levels with an existing dc system. It wouldn't be possible for me to use an ac source for lighting.

Right now I'm in the process of exploring the feasibility of adopting the new high-lumen-output lamps you mention in such a scheme. Once again, many thanks for publishing this article.

N A DANNER, *New Orleans, La.*

. . . I find nothing in the report concerning the effect of varying voltage supply on life of high-output lamps. This has been a problem peculiar to our plant for many years because of the nature of our process. The article could have been improved by giving more information on voltage both from a standpoint of life expectancy and of light output. Otherwise, I think it was a job very well done.

J S HARBOLD, *East Chicago, Ind.*

. . . As an engineer who travels a great deal in this country and abroad, the "typical recommended illumination levels in foot-candles" shown on p 53 of your report left me a little cold. I know it is important to have recommended values established in many engineering areas. However, in the area of lighting I find so many plants—yes, even newly designed plants—with a lighting level that falls far short of what I consider good lighting today.

I think POWER could serve its readers by rounding up some *average* lighting levels found in typical plants within a given industry and comparing them to recommended levels. It would show the magnitude of the job lighting engineers have to do before actual values become recommended values.

C R VANDERFRIES, *San Francisco, Calif.*

Apodes with anodes and cathodes

Your article covering various ways of generating electricity—including some I had never heard of—was tremendously interesting. (*More ways to generate electricity*, Feb 1959, p 55). However, you made no mention of electric eels. Perhaps you'd be interested in knowing something about them.

Large electric eels put out a maximum of about 600 v with a low amperage (about ¾ amp). Output is determined by distance between any two of the eel's electrodes. The further apart they are, the more battery cells in between and the greater the voltage. Electricity is produced in modified muscle cells which are different in different kinds of electrical fishes. Electrical eels have three kinds of generating organs which operate at different pulsations. Polarity varies according to the type of fish. The electric eel is positive on the head and negative on the tail. The African electric catfish's polarity is the reverse of this. Electric rays, found in San Francisco Bay, are positive on the supper surfaces of the body and negative on the lower surface. Apparently eel discharge is similar to that of a condenser; a heavy discharge, then a recuperative period.

There's an increasing amount of literature on the subject of electric phenomena among fishes. Recently, about six new types were discovered with a microvoltage output which is used by the fish in the same manner as modern sonar.

G ROSEKILLY, *San Mateo, Calif.*

EDITOR'S NOTE: *Eel-watts previously received special mention* (Speaking of POWER, *Dec 1958, p 5), consequently weren't netted for the* TD *report.*

Send the gin prepaid

Your old Marmaduke Surfaceblow is usually pretty good at coming up with a "horse-sense" solution to an apparently baffling problem. But how can he be so aware of modern practice and still date himself back to the old "walking-beam" days with his cure for popped rivets? (*Marmy's loose rivets*, Jan 1959, p 134.) I would like to see him try his method for rivets in the bottom of a ship's keel. Here's a rough sketch of a rig I used on tankers 15 years ago. If Marmy doesn't think it's better than his way, I'll buy him a bottle of Sandpaper Gin.

H H LEIDOLF, *Salem, N. J.*

EDITOR'S NOTE: *Steve Elonka took the sketch over to the salty old consultant's office in Hell's Kitchen. Marmy took one look at the sketch. "All that jury rig for a popped rivet in the keel?" he snorted. "I never was on a bucket that had that trouble, but we could'a fixed it easier than that. Every ship has a deckswab that could stand a good keelhaulin' so we'd just stick a bolt, gasket and washer in the guy's fist and have him fit them in the rivet hole as he went past." With these words, Marmy returned to his bottle of Sandpaper Gin, so Steve came back to the office to report his helpful suggestions.*

Steam trap dependability is a matter of what the manufacturer puts into the trap

ARMSTRONG TRAPS ARE DESIGNED AND MADE TO GIVE YOU DEPENDABILITY

1. Efficient, proved operating principle

Armstrong Traps provide the most advanced development of the time-proven inverted bucket principle. Simple, but effective, there isn't much that can go wrong.

2. Good design

Armstrong Trap design gives big capacity in a small package. The mechanism is virtually fool-proof. All body styles are easy to inspect and maintain without removal from the line.

3. Highest quality materials of construction

Only the best goes into Armstrong Traps. Bodies are close grained 30,000 tensile iron castings or high quality forgings. Working parts are all tough, corrosion resistant stainless steel.

4. Good workmanship

Armstrong Traps are made by craftsmen who take pride in their work. Careful inspection and frequent checking insure the quality of the trap.

5. Application know-how

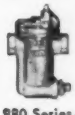
Your problem has probably been solved already in the extensive experience of the Armstrong engineering and sales organization. You can be sure of sound, dependable recommendations.

Your local Armstrong Representative can show you what Armstrong dependability can do for you. Call him today or write direct.

860 Series for low pressure heating service.

800 Series, side inlet, side outlet.

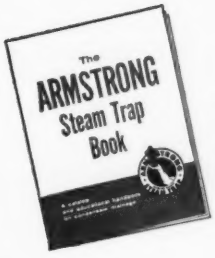
No. 801, side inlet, bottom outlet.



880 Series, integral strainer.

200 Series, bottom inlet, top outlet.

Forged Steel Series for high pressures, high temperatures.



The 48 page Armstrong Steam Trap Book tells how to correctly size, install and maintain steam traps for any pressure, any temperature, any load plus full catalog data on Armstrong Steam Traps. Ask for Catalog K.

ARMSTRONG MACHINE WORKS

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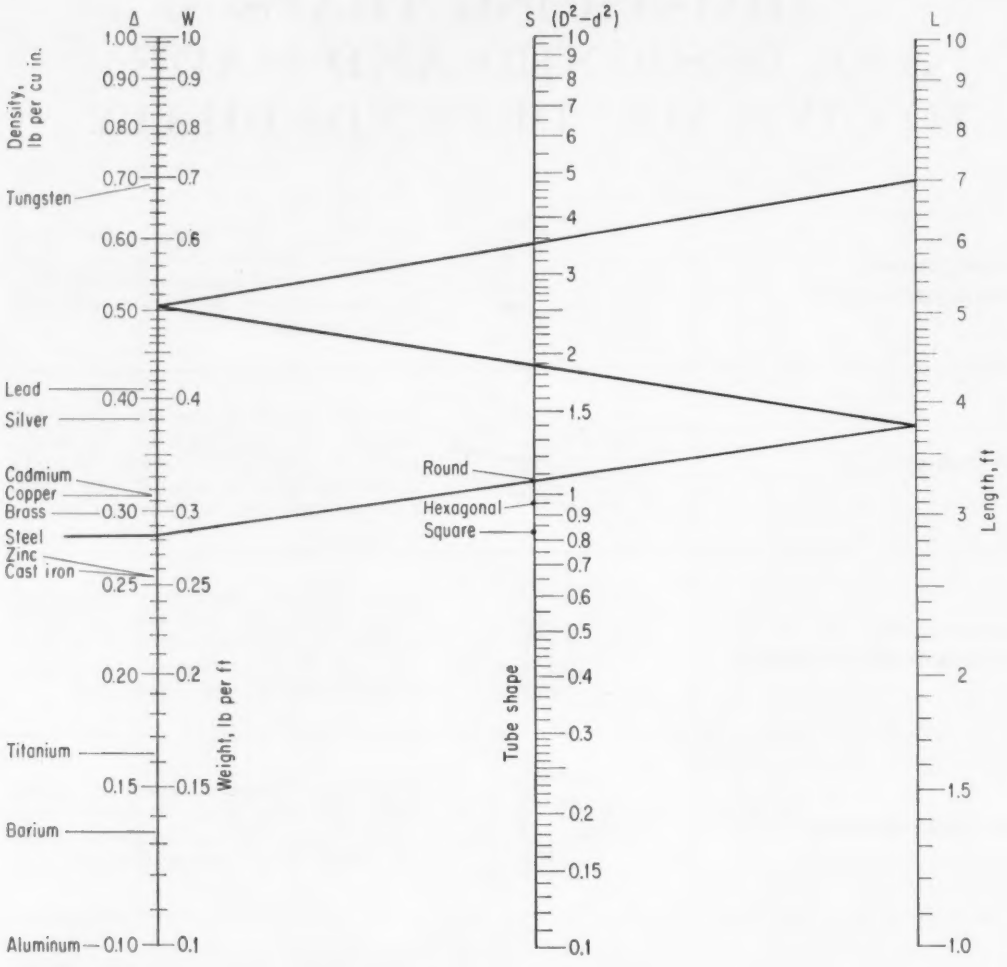
For more facts circle 250 on Reader Service card, p 125

Power's data sheet

No. 322



Weight of tubes and solid rods

This nomogram helps figure weight per foot or total weight of either tubes or solid rods of metals. Most metals are spotted on the left-hand density scale Δ in lb per cu in.

To use, first find metal or its density on the Δ scale. Next find index point for *round*, *hexagonal* or *square* shape on center *S* scale. Connect two points with straightedge to intersect right-hand scale as a pivot. Then from OD and ID of tube, figure $D^2–d^2$ or find D^2 of solid rod and locate on center scale. Connect right-hand scale intersection to this point and find weight in lb per ft on left-hand *W* scale. Finally, find length of tube or rod on right-hand *L* scale, connect with reading on *W* scale and read answer on center scale in total weight, lb. Now let's see how this works out.

Example: Find weight of seven feet of round steel tubing with 1-in. OD and 0.901-in. ID. Find steel density at 0.283 on Δ scale, connect with *round* index on *S* scale to intersect with the right-hand scale. Calculate $1^2–0.901^2 = 0.188$ and locate on center scale. Connect with right-hand intersection and project to read 0.502 lb per ft on *W* scale. Connect this with 7 on *L* scale and read answer of 3.5 lb on center scale.

—S Salva and W R Morey, *Jackson, Mich.*

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O.S.&Y. U-BOLT GATE

MADE BETTER THAN NEED BE . . .

Costs Less to Use

YOU PAY NO MORE for the extra quality you see in every part of a Jenkins Outside Screw & Yoke U-Bolt Gate valve. Yet longer life and reduced maintenance is bound to result from the extra ruggedness, the precision manufacture and unique design features which Jenkins puts into these popular, general utility valves.

Choose the Outside Screw & Yoke pattern for services where spindle threads must be kept out of the destructive effects of fluids in the line; where spindle threads must be cleaned and lubricated regularly or where a rising spindle is needed to indicate wedge position.

Choose JENKINS, whether O.S. & Y. or Inside Screw pattern, for valves built to save maintenance dollars.

WIDE RANGE OF JENKINS U-BOLT GATES

GET FOLDER NO. 207 which describes Inside Screw and O.S. & Y. patterns . . . Iron Body with Bronze or Stainless Steel Mounting . . . All-Iron and Ni-Resist with type 316 Stainless Steel trim. Ask your local Jenkins Distributor or write Jenkins Bros., 100 Park Avenue, New York 17.

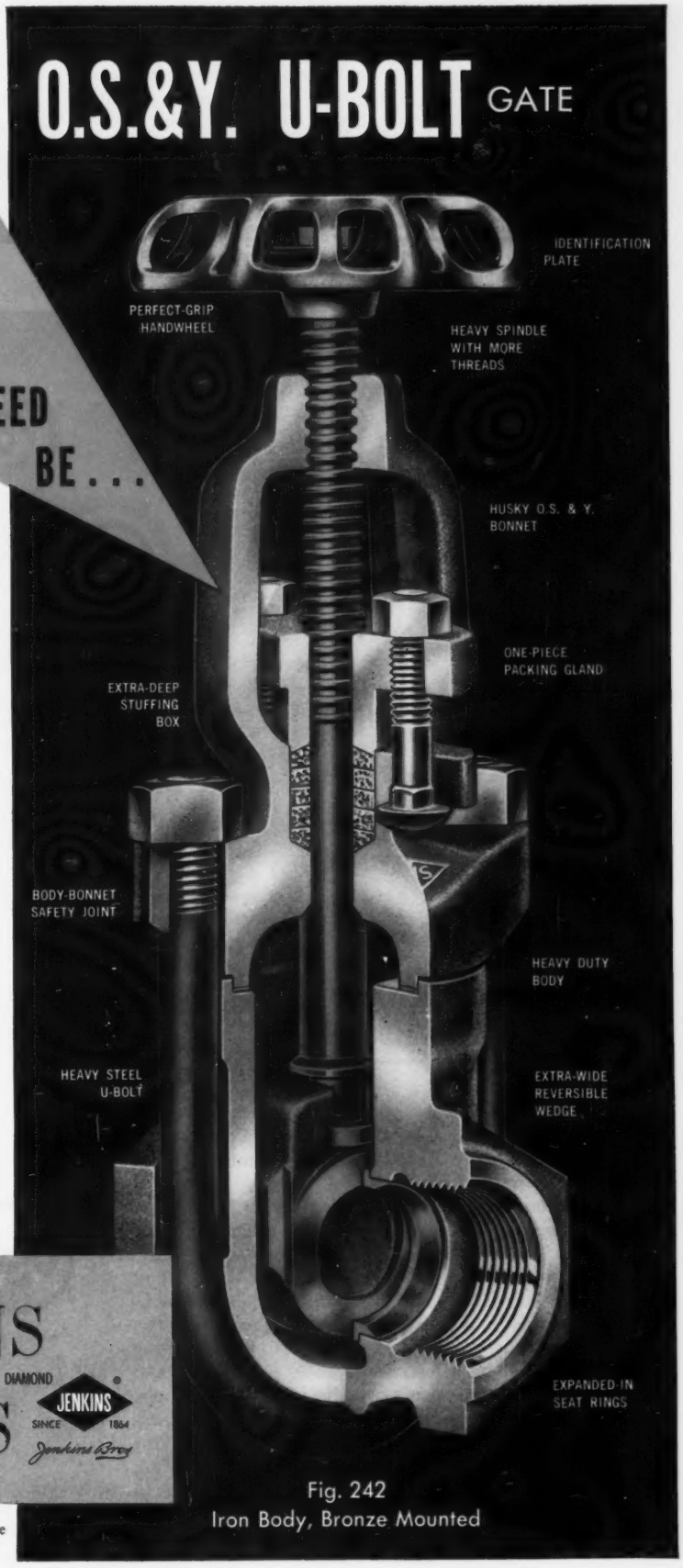

Fig. 242
Iron Body, Bronze Mounted

JENKINS VALVES

LOOK FOR THE JENKINS DIAMOND

JENKINS SINCE 1864 Jenkins Bros

Sold Through Leading Distributors Everywhere

For more facts circle 251 on Reader Service card, p 125

The face of a commercial center

Architects and Engineers: Lane, Gamble and Associates; General Contractors: Robert E. McKee, Inc., and J. E. Morgan and Sons; Heating and Plumbing Contractors: Kieffer Plumbing and Heating Co., and Sam P. Wallace and Co.; Mechanical Engineers: Blum and Guerrero, and William K. Hall and Co.

. . . and its heart

THIS IS EXCHANGE PARK IN DALLAS, TEXAS—a 125-million dollar commercial development of five multi-story office buildings, a regional shopping center, a hotel and a complete medical center.

Over 300 tons of USS National Seamless Pipe in sizes from 2⅜″ through 24″ were used in the heating and cooling system which serves the center from a utility plant. Steam at 250 psi working pressure is generated in the utility plant by five 50,000-pound boilers whose combined steam capacity is 250,000 pounds. This plant also has a refrigeration capacity of 12,000 tons, supplied by a system capable of handling close to 34,000 gallons of condenser water per minute, and is capable of meeting the needs of a city with 36,000 people.

Do you need quality pipe for power, heating and air-conditioning installations? You'll get it when you ask for "NATIONAL PIPE." If you'd like further information or immediate assistance with your pipe problems, write to National Tube Division, United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

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USS National Tube Division of United States Steel

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Decision made 21 years ago proved to be the right one

Garnett, Kansas Light Plant in 1938, selected Standard Oil diesel lubricant

Situation: In 1938, when Garnett, Kansas put two diesel engines (one 600 hp and one 1000 hp) into service, plant management selected a Standard Oil diesel lubricant. In 1948, when a 1400 hp engine was added, the performance from the Standard lubricant caused management to make the same choice. In 1955, when a 2100 hp duel fuel unit was placed in service, STANODIESEL Oil M was chosen.

What has happened: At the Garnett plant, stuck rings and dirty pistons are unknown. The 1400 hp unit was in service nine years before reringing. Overhauls are made only every five years. The top performance from STANODIESEL Oil M and the technical service provided by lubrication specialist, J. D. Jenkins, have made possible first rate, uninterrupted, low cost electric service.

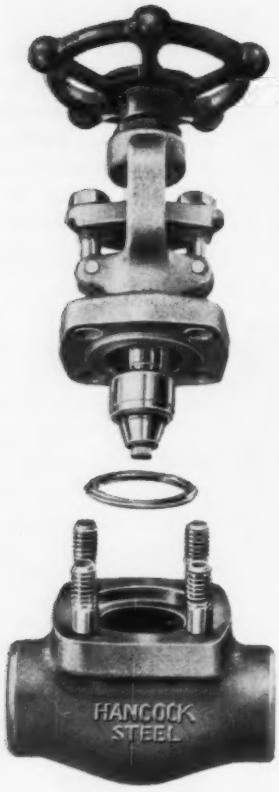
What you can do: The Standard Oil salesman near you in any of the 15 Midwest or Rocky Mountain states has the full story about STANODIESEL Oil M, and how it will perform for you. Call him. Or write, **Standard Oil Company (Indiana), 910 S. Michigan Ave., Chicago 80, Illinois.**

You expect more from **STANDARD** *and you get it!*

Quick facts about
STANODIESEL Oil M

- Keeps crankcase, pistons, cylinder walls clean.
- Combats deposit and wear problems imposed by the use of economy fuels.
- Maintains film on difficult-to-lubricate parts.
- Eliminates fuel injector and pump sticking caused by deposits on injector barrel and plunger where fuel and lube oil mix.

Garnett plant superintendent John Watkins (left) and Standard Oil's J. D. Jenkins inspect light plant's 2100 hp unit lubricated with STANODIESEL Oil M. Jake Jenkins knows what he's talking about when he advises customers on lubrication. He's been doing this work for 13 years. He has an engineering degree from Missouri School of Mines, and he has completed the Standard Oil Sales Engineering School.



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shuts off costly maintenance

Hancock 600# Steel Valves incorporate new concepts in valve-ology that reduce valve maintenance and equipment down-time. The forged steel bonnet and body have butting flanges so strong no distortion is possible. The flanges form a bonnet joint that utilizes the sealing power of a Flexitallic* gasket so effectively not even pressures exceeding ten times the rating of the valve can cause a blowout.

Hancock valve-ology makes full use of stainless steel to reduce your valving cost. Seat, disc, stem, swing bolts and nuts, thread bushing, packing gland follower—all are stainless steel. Globe, Angle, "Flocontrol", Lift Check, and Hi-Pressure Drop designs available. A high degree of standardization simplifies servicing and inventory needs. Your industrial supply distributor will gladly give you full details on Hancock Valve quality and performance. Phone him today.

Hancock 600# Steel Globe Valve. Type 5500 Line. Sizes: ¼" thru 2".

*Trademark of Flexitallic Gasket Company

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A product of

MANNING, MAXWELL & MOORE, INC.

Consolidated Ashcroft Hancock Division • Watertown, Massachusetts
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

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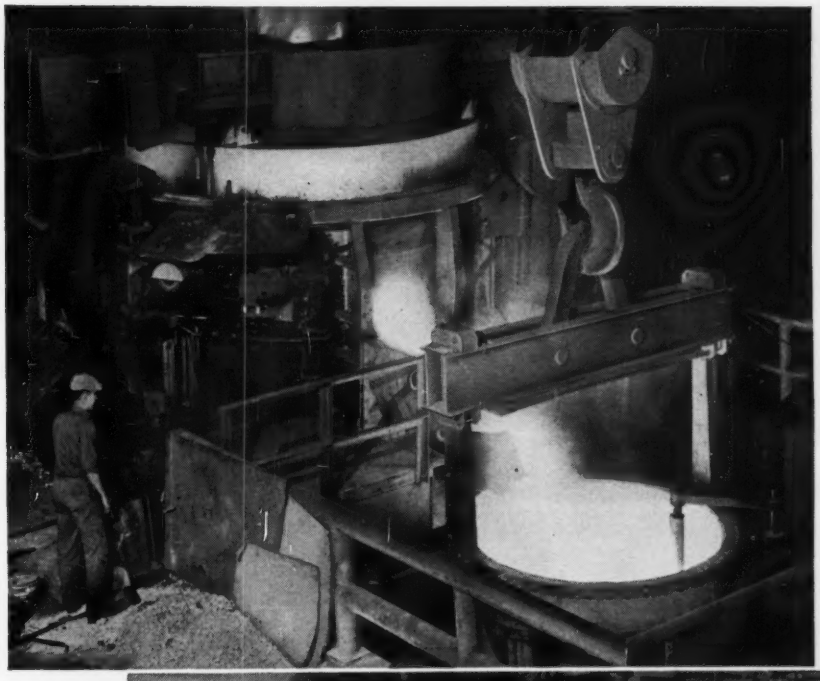

Tapping a 50-ton arc furnace at B&W Barberton works.

Rigid quality control is maintained through all phases of production down to final inspection.

Why B&W Hollow Forged Piping Gives Long, Dependable Service

At B&W, quality control of Hollow Forgings is constant from initial melt to final inspection of the finished product. This *integrated* control is a big reason why B&W Hollow Forged Piping is the most practical choice for main steam, reheater, feedwater, and other heavy-duty high-pressure or high-temperature lines.

Testing at B&W includes analysis and grain structure examinations—hydrostatic test—and ultrasonic test as standard procedure. What's more, B&W machines the outside surface of every forging, to assure good appearance and ease of fabrication.

B&W Hollow Forged Piping is available in a wide range of sizes, in carbon, alloy and stainless grades, and is made to ASTM specifications. There is a size and grade close to your optimum design requirements. For more about how B&W Hollow Forgings meet your needs best, write for Bulletin S-16. The Babcock & Wilcox Company, Boiler Division, Barberton, Ohio.

B&W

THE BABCOCK & WILCOX COMPANY

BOILER DIVISION

S-475-HF

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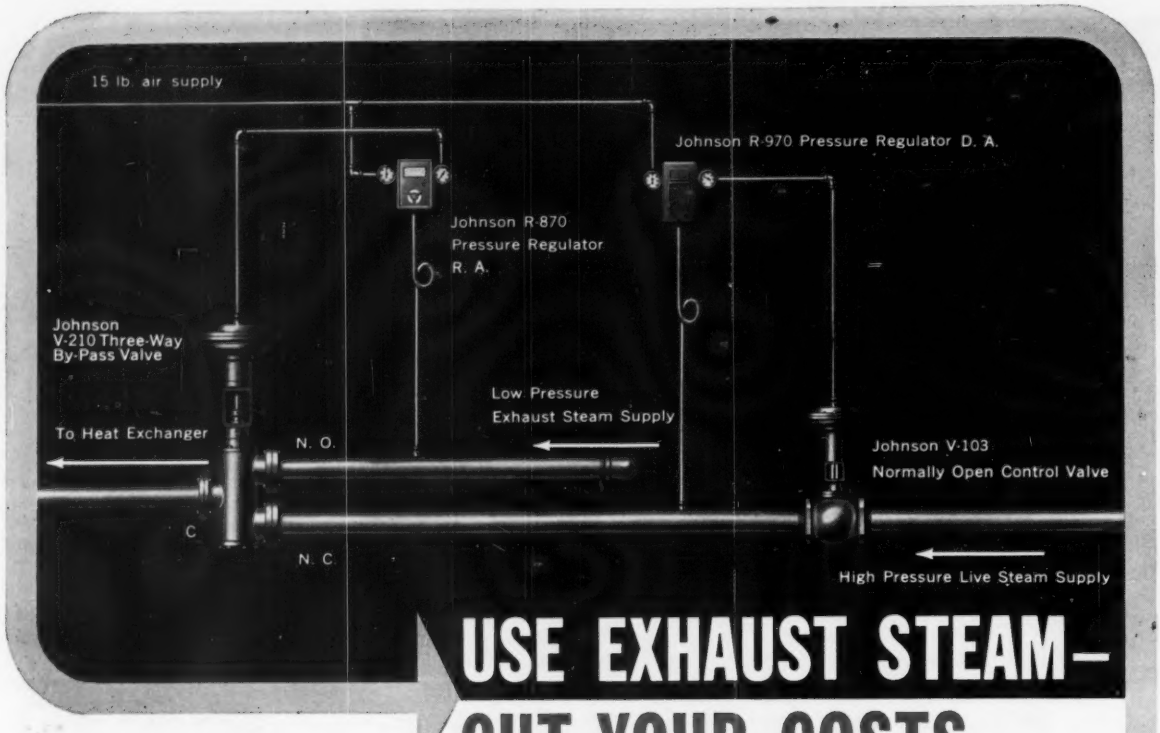

USE EXHAUST STEAM— CUT YOUR COSTS

Johnson Control Hook-up Switches to Live Steam Only When Necessary

This simple control installation saves substantially on the consumption of live steam. And the savings are automatic!

Operation of the hook-up is positive and dependable. As exhaust steam pressure builds up to usable level, the Johnson Pressure Regulator activates the Three-Way Valve. The valve then shuts off the live steam and admits exhaust steam to the line. When exhaust pressure drops, the process is reversed.

Heart of the hook-up is the Johnson Three-Way By-Pass Valve. The 100% tight-closing design of this valve enables it to do the work of *two* ordinary valves. It can be piped straightaway for easier, less costly installation. Discs and seat rings can also be replaced with the valve in the line . . . for still further savings in maintenance.

Here is a method which can produce large economies for you by utilizing exhaust steam. Its effectiveness has been proved in scores of installations. For further information about the controls used, mail the coupon below.

JOHNSON SERVICE COMPANY
507 E. Michigan Street, Milwaukee 1, Wisconsin 989

Please send me your apparatus bulletins describing the following equipment: ☐ R-870 Pressure Regulator ☐ R-970 Pressure Regulator ☐ V-210 Three-Way By-Pass Valve ☐ V-103 Normally Open Steam Control Valve ☐ New Condensed Catalog of All Johnson Equipment ☐ Have a Johnson engineer call.

Name & Title.....

Company.....

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City..... Zone..... State.....

JOHNSON CONTROL
SINCE 1885

DESIGN • MANUFACTURE • INSTALLATION • SINCE 1885

6 Ljungstroms® go to work for the city of Memphis ...and so does lifetime Air Preheater service

The City of Memphis Light, Gas and Water Division has just installed three boilers served by six Ljungstrom preheaters. Why Ljungstrom preheaters? One reason is service. Air Preheater engineers don't just wait for a call. They regularly inspect and help maintain Ljungstroms *through the life of each unit.*

What's more, Air Preheater provides rapid *factory* service in an emergency. Here's an example. A customer phoned on a Friday morning for a replacement trunnion—a major integral part of the preheaters. His Ljungstrom was 17 years old, which meant that a new trunnion had to be custom made to match his older-style. He was located 500 miles away. And he needed his boiler back on the line by Sunday.

Air Preheater went to work. Special trucking was arranged. The job was done *and shipped* that same evening. The customer had the trunnion by Saturday morning and the boiler was back on the line by Saturday evening!

Fast response to emergencies and regular inspection of Ljungstrom installations are two of the many advantages Air Preheater provides its customers. Another is expert knowledge of boiler and preheater problems —and how to lick them—gained from over 35 years of experience. Perhaps these reasons explain why 9 out of 10 preheaters sold today are Ljungstroms. For further information write today for free illustrated brochure.

THE AIR PREHEATER CORPORATION

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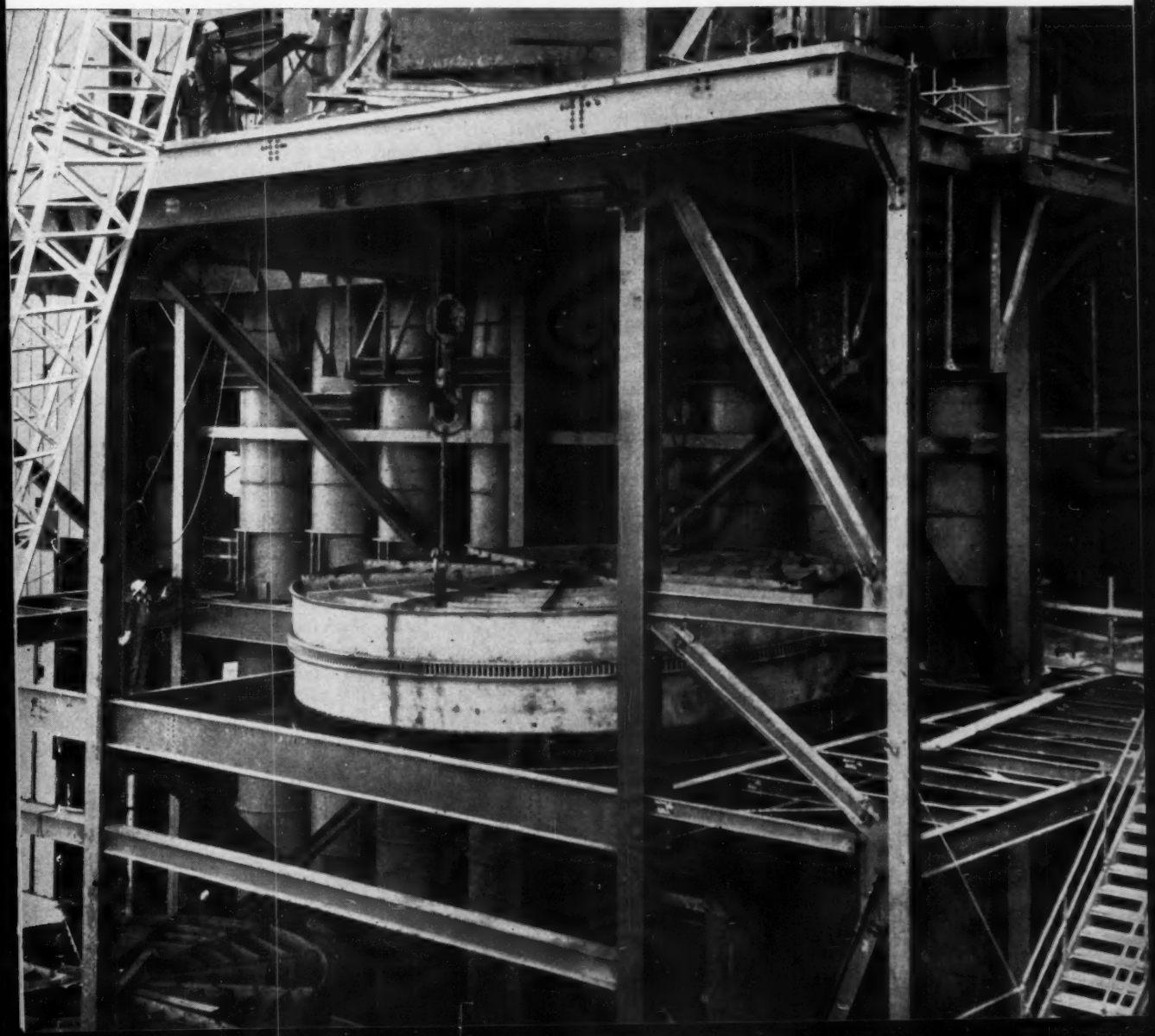

Ljungstrom rotor being installed for the City of Memphis Light, Gas and Water Division. Six such Ljungstroms—each with 201,400 sq ft of heating surface —will serve three boilers. The boilers will each evaporate 2,000,000 lbs of steam/hr and have a combined nameplate capacity of 750,000 kw. A fourth boiler unit is now under consideration. Burns and Roe, Inc. designed and supervised construction.

Technical briefs . . . Latest engineering

Insulation power-factor test, generator-coil electrical position determine coil reuse

Evaluation of the internal insulation of generator coils based on power-factor measurement, *D A Findlay, R G Brearley and C C Louttit, Aluminum Company of Canada, Ltd*

Power-factor measurements and tests are now used to spot breakdown of internal insulation of electric-generator coils. Power-factor tests were applied to mica-insulated coils of a 35,000-kva 13,200-volt waterwheel generator after 12 years' service. The results were correlated with visual inspection and other tests on the same coils and with power-factor tests run on coils built for duplicate machines in the same powerhouse. Examination showed the coil's electrical position (in a parallel referred to line or h-v end of parallel) had much effect on test-result evaluation. In the generator examined there are 30 coils per parallel, with position 1 the line end and position 30 the neutral end.

Each coil was power-factor tested and amount of tip-up calculated. (Tip-up is rise in power-factor curve from a straight line due to voids in insulation.) Results of tests and examinations of coils isolated four categories which help determine acceptability of old coils in new positions:

(a) Coils with tip-up less than 1.9% regardless of electrical position and coils with tip-ups between 2.0 and 2.4% from position 16 to 30 were not restricted to position.

(b) Coils with tip-ups of 2.0 to 2.4% from position 1 to 15 and coils with tip-ups of 2.5 to 2.9% from positions 16 to 30 could be reused in mid-position, but not above position 10.

(c) Coils with tip-ups of 2.5 to 2.9% from positions 1 to 15 and coils with tip-ups of 3.0 to 4.5% from positions 16 to 30 are good for neutral-end coils, not to be used above position 20.

(d) Coils having tip-ups of 3.0% and over in positions 1 to 15 were scrapped.

These coils were then tested with an ac high-potential test of 30 kv to ground and all but nine of the 280 reusable coils in groups 1 to 3 passed. The 271 remaining coils were tested by dc high potential of 45 kv to ground and all passed.

The power-test technique might be applied to all mica-insulated coils of this type regardless of age. *AIEE paper 59-25*

Directions for ordering these papers on page 116

Electrical equipment

Inner-cooled shell for power transformers, *W D Albright and H R Moore, Westinghouse Electric Corporation*

Most oil-insulated transformer designs include areas of high stress where there is only oil for an insulator. Since oil-impregnated pressboard has a higher dielectric strength than oil a more efficient design would aim at reducing or cutting out the high-stress oil-filled areas.

A recent design accomplishes this aim and at the same time results in more kva capacity at higher voltages for the same size as present transformers. *AIEE paper 59-43*

Adjustable speed control of ac motors, *L R Foote, General Electric Company*

Speed control for hoist motors helps position loads accurately and set them down gently. Requirements for variable-speed hoist motors are: (1) weight cannot vary load speed appreciably (2) load should accelerate smoothly from suspended position (3) drive must change speed without shock or speed overshoot and (4) maintenance should be simple.

An alternating-current motor speed control meets these requirements. Control is gained by three saturable reactors, one of which has two power windings and acts as a saturable transformer. Magnetic amplifiers control reactor excitation and static regulating action provides forward or reverse phase sequence for either driving or retarding torque. Two sets of resistors and a closed iron non-regulated reactor make up the rotor circuit and provide uniform maximum torque at all speeds.

Three-element control provides low cost and simple installation. Continuous speed adjustment through zero sets hoist down easily. *AIEE paper CP 59-84*

A novel type of smoothly variable-speed ac motor having widely adjustable power factor characteristics, *P K Charlu, P S G College of Technology, Coimbatore, South India*

A new approach to variable-speed motors is an ac motor with a dc-excited stator and an armature fed by two-phase ac variable voltage (by synchronously revolving brushes). The motor combines the smooth adjustable-speed characteristics of a dc unit and the power-factor control of a synchronous motor. It can be operated on single phase with series- and compound-connected excitation and as an auto-synchronized converter if it is supplied with more brushes than standard design number.

Unit is still in the experimental stage and certain improvements are needed, but it's hoped to apply the design to full-scale motors. *AIEE paper 59-136*

developments for busy power men

12 papers for you on:
WATER TREATMENT
GAS TURBINES
ELECTRICAL SYSTEMS

Water treatment

An evaporator vapor purity test using the sodium tracer technique. *H R Lawrance and R J Ziobro, Griscom-Russell Company*

A total of 230 test runs were completed on an evaporator in a 6-month period. Shell-brine sodium content and conductivity were determined for each run and total shell-brine solids were determined gravimetrically every sixth run.

Test included operation of evaporator with and without centrifugal and mesh separators. Studies were also made on effect of turbine load changes and causes of fogging and foaming.

Results show evaporator vapor of less than 10 parts per billion total dissolved solids over a wide range of vapor flows is obtainable. Locating splash baffle properly permits level increases up to 5 in. (adequate for the displacement type controllers) without seriously affecting the vapor purity. Moisture separators aren't necessary, although a simple centrifugal separator gives added protection against carryover during abnormal operation. Mesh separators failed to prevent severe carryover during abnormal operation and authors believe this limits use of the mesh in high-purity applications. Finally, authors indicate fogging is a major cause of low vapor purity at low loads. Better results are obtainable by keeping tube bundles completely submerged. *ASME paper 58-A-237*

"Thermiatrics," the diseases of high-temperature boilers, *D E Noll, Hall Laboratories, Division of Hagan Chemicals and Controls, Inc*

"Geriatrics" concerns the diseases of old age in humans; "thermiatrics" is coined to cover the diseases of boilers caused by formation of iron oxides in areas of high temperature. The analogy is particularly apt since surgery is often the best and only solution to both troubles.

Tube failures in the central stations today (high temperature, high pressure) often result from a growth of iron oxide in regions of high heat transfer. The most important factor affecting the growth rate is temperature. Although the symptoms and cause of the disease are known, the cure isn't. Three proposed chemical treatments are aimed at preventing the trouble rather than curing it once it appears. And acid cleaning falls in the same category: an act aimed at preventing development of an oxide to the point where damage results. None of these are particularly good since they require knowing ahead of time when to treat the unit. Hope is therefore expressed that the cure will be in the development of metals which resist the oxide growth in the first place. *ASME paper 58-A-277*

Disposal of water-treatment wastes, *E G Paulson, Hall Laboratories, Division of Hagan Chemicals and Controls, Inc*

Major river and stream contaminants produced by a water-treatment plant are alkalinity, acidity, suspended and settleable solids. Present equipment and techniques will take care of these at reasonable cost. Dissolved solids are another problem, not so easily solved.

Hot or cold lime or lime-soda softening, filtration, clarification, zeolite softening and demineralization all produce wastes. Not all these wastes represent contamination problems, but all are discussed as to the type of waste and best available treatment or solution to the problem. *Engineers' Society of Western Pennsylvania*

Developments in the understanding of ion exchange, *L F Wirth Jr and A M Franklin, Ion Exchange Division, National Aluminate Corporation*

The last few years have been active ones in the ion-exchange field. After gel zeolites came phenolic cation exchangers and styrene cation-exchange resins. Then higher-density cross-linked cation resins doubled usable life in hot-zeolite installations.

More recently mixed-bed demineralizers at high flow rates have done a good job except for high-pressure losses. High pressure, plus dehydration and excessive chemical exercise, leads to resin-bead breakage. Generally, anion resins stand up better in resisting breakage than cation resins. Cation beads larger than 30 mesh are the most susceptible to breakage. One way to overcome the pressure problem is to increase particle size and decrease uniformity coefficient. Authors discuss developments now going on at their labs to overcome some of these problems. *Engineers' Society of Western Pennsylvania*

Two-bed primary system solves mixed-bed demineralizer problems at Philadelphia Electric Company—Cromby Station, *H C Farmer, Philadelphia Electric Co, and S B Applebaum, Cochrane Corp*

Cromby Plant of Philadelphia placed a two-unit demineralizer in operation in March, 1954. Each unit was 42 in. in diameter, rated at 50 gpm, and contained 32 cu ft of styrene cation resin and 40 to 45 cu ft of Type II porous anion resin. Two activated carbon filters, 54 in. in diameter, preceded the demineralizers. These last were to remove organic matter found in city water.

By April, 1955 capacity of beds had dropped from 50,000 to 5000 gallons. Resin was added then and in Jan, 1955 to reduce silical leakage. Attempts to clean resins with acid did not help. In April, 1955

continued

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ductile iron steam traps
give you cast steel service
at less than half the price!*

Strong's new 540 series Hydro-Flex Steam Traps are made of DUCTILE (NODULAR) Iron that can be bent or twisted without breaking. This newest metallurgical development, adopted by ASME*, enables Strong to produce traps for service up to 500 psi and 650°F with ample safety factor. Ductile Iron economy permits sale of these traps at less than half the price of comparable cast steel traps.

*Ductile (Nodular) Iron meets the requirements of the ASME Code for use in vessels at pressures to 1000 psi and temperatures to 650°F (80% of cast steel service).

1. Safer to use because Ductile Iron body and cover will bend or twist in case of explosion or fire whereas brittle materials might shatter or break.

2. Especially recommended for drainage and drip service on high pressure steam systems and on both high and low pressure systems in chemical plants and refineries where steel is normally required.

3. Wide choice of sizes and capacities: Pipe sizes from ½" to 2", capacities to 42,800 pounds of water per hour.

4. Connections: Traps with screwed connections regularly furnished. (Although Ductile Iron can be welded or brazed under controlled shop conditions, welding is *not* recommended for field fabrication.)

Strong 540 Series Ductile Iron Traps are available from your local Strong Distributor. Call him for more information, or contact . . .

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508 SANDUSKY STREET • CONNEAUT, OHIO
air traps • strainers • reducing valves • vacuum or pumping traps
continuous blowdown valves • separators • engine stops • F and T traps

Technical briefs

Begins on page 110

entire resin bed was replaced, but the drop started again. And the carbon filters didn't work well. Although steamed daily they failed to filter the organic material. Filters were replaced twice before being discontinued. Final solution was installation of a two-bed primary system to operate mostly in series with the mixed-bed units. For extra capacity units can be operated in parallel. *APC paper 4.44*

Electrical systems

Voltage - drop determinations examined, *R A Erwin, Department of Water & Power, Los Angeles, Calif.*

There is a real need for examination into the subject of voltage drop on industrial and commercial types of wiring, and for the eventual adoption of criteria that will facilitate the determination of factual evaluations. The National Electrical Code recommends values of drop for feeders but makes no reference to branch-circuit or overall drop, and states no method for determining drop. Nor does any other nationally recognized authority.

Because of the lack of authoritative procedures, many conflicting charts, graphs, diagrams, slide rules and formulas have been published. Some are reasonably accurate but tedious to apply, others are grossly inaccurate.

The author suggests that a reasonably accurate method should be established and adopted, and that the most practical way to do this is to make voltage drop checks on a great many existing installations. This would require cooperation of several of the larger industrial concerns. *AIEE paper, CP-58-102*

Lightning protective requirements of generators connected to the system through wye-grounded-delta transformers, *J K Dillard, A R Hileman, Westinghouse Electric Corporation*

Recent years have seen a renewed interest in evaluating lightning protec-

Directions for ordering papers on page 116

COPPUS BLUE RIBBON PRODUCTS

Coppus Steam Turbine with Built-In Speed Reducer

STAMINA — You can literally *see* stamina in every dimension of a Coppus Turbine . . . rugged reliability that assures you stable, positive performance. It truly "wins" the Blue Ribbon with which it is marked . . . through advanced design, top quality materials, and thorough testing. With Coppus you're always certain of Blue Ribbon features such as these —

A totally enclosed governor . . . totally enclosed, independently operated safety trip . . . easily replaceable packing and bearings . . . multiple steam nozzle control . . . brake rim for added safety . . . wide bucket "L" type wheel (optional) for minimum water rate.

Coppus Turbines are built to customers' specifications, including API and NEMA standards. Sizes from 1 HP to 250 HP. All Coppus Products carry the same Blue Ribbon assurance of reliable performance. For further facts on turbines, send for new Catalog 200. COPPUS ENGINEERING CORPORATION, 166 Park Ave., Worcester, Mass. Sales Offices in *Thomas' Register*.

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STEAM TURBINES

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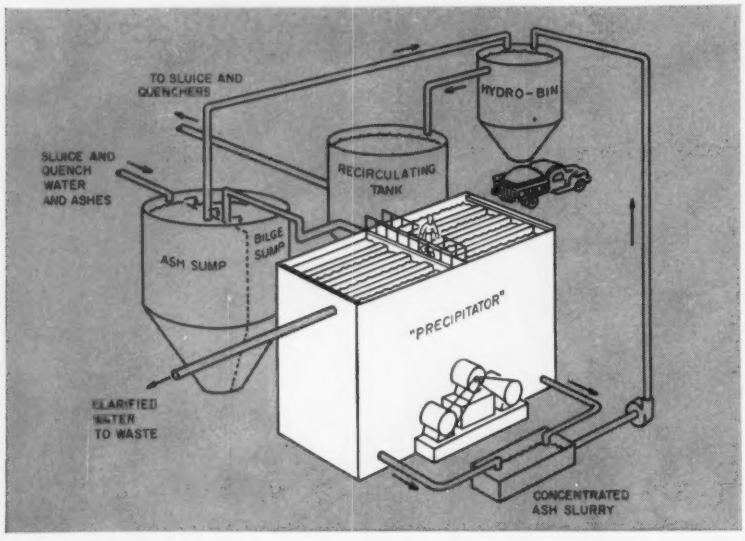
is a Pfaudler Permutit program providing
the know-how
the equipment
and the experience
for solving problems involving fluids



FLUIDICS AT WORK

Precipitator separates 15 to 25 tons of ashes per day for U.S. Rubber Co.

. . . makes ash-handling system flexible, dependable.

Ash problems at U. S. Rubber's Detroit plant are typical. The powerhouse has widely varying loads . . . requiring a flexible ash-handling system. The system must also be dependable, because all clarified effluent water goes into the Detroit River and this water must not contain suspended solids that could obstruct the river channel.

Tests were run at U. S. Rubber's plant using a pilot-scale Permutit Precipitator. As a result of these tests, a 300 gpm horizontal unit was installed. (See simplified flow chart.)

U. S. Rubber's Permutit Precipitator goes a long way to make their system successful. In use over 2 years, the Precipitator handles varying loads of 15 to 25 tons of suspended ash per day . . . at low cost without coagulants or other chemicals . . . yet it always delivers effluent water as clean as the river water itself.

Pfaudler Permutit offers impartial advice about water treatment . . . based on experience with all basic types of solids separation processes—coagulation, settling, flotation, centrifuging, evaporation and ion exchange. Write to our Permutit Division, Industrial Waste Treatment Dept. PO-69, 50 West 44th St., New York 36, N.Y.

FLUIDICS covers such varied phases of fluid handling and control as:

water treatment	metering
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PFAUDLER PERMUTIT INC.

Specialists in FLUIDICS . . .
the science of fluid processes

Technical briefs

Begins on page 110

tive equipment needs at the terminals of unit-connected turbine-generators. Several factors—better arrester characteristics, better insulation, higher cost of space, need for high unit reliability—have led to re-evaluating the problem because of increased desire to omit any equipment not essential to system operation.

Therefore the authors have presented in this paper a procedure for determining exactly what protection is needed and when you can safely cut out lightning devices. Arresters located adjacent to and remote from transformer terminals are considered, in addition to a case for a three-winding transformer and effects of 60-cycle voltage.

For single-turn-per-coil generators, surge capacitors at the generator terminals are not required for lightning protection. *AIEE paper 58-1170*

Gas turbines

Automatic 10-mw gas-turbine power station, *J R Schnittger, STAL, Finspang, Sweden*

A 10-mw gas-turbine power station is now on-line in Varberg, Sweden, installed in an existing steam power station; bringing the unit on-line or taking it off is completely automatic.

Since calculations showed heat-exchanger effectiveness must exceed 55% efficiency before a recuperative cycle would pay, a simple cycle was employed for the installation. The gas turbine supplied includes only the compressor, combustion chamber and turbine.

Better thermal efficiency at partial load and compressed-air starting are advantages at this station. Power turbine is free-running, with an efficiency at half-load of 84% against efficiency of 71% if the turbine and low-pressure rotor are physically connected. The three rotational sections have speeds of 5200 rpm for the low-pressure rotor, 6350 rpm for the high-pressure rotor and 3000 rpm for the power turbine-generator. Generator output drops from a maximum of 12 mw at 20-F outside air temperature to 7.6 mw at 86-F outside temperature. The efficiency for this spread

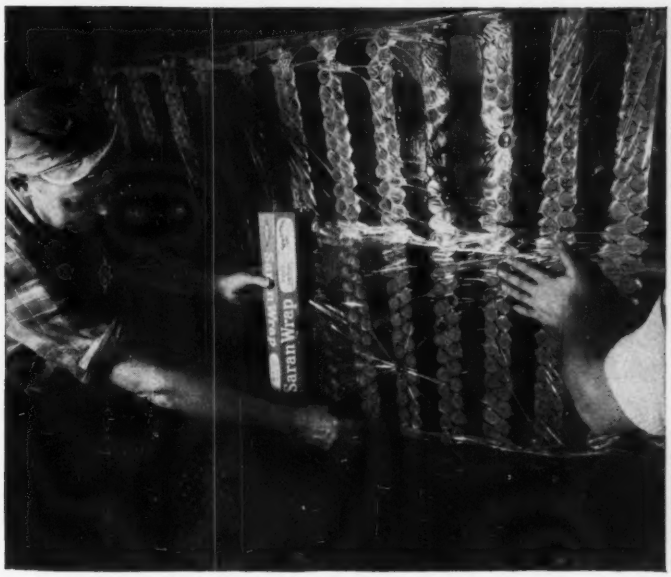
Directions for ordering papers on page 116

BRIDGEPORT BRASS

COPPER ALLOY BULLETIN

CONDENSER AND HEAT EXCHANGER TUBE EDITION

Plastic Film Detects Condenser Tube Leaks Without Turbine Shut Down



Maintenance crew spreads plastic film over still-wet tube sheet—a simple, fast operation.

Leaking tube is quickly identified when vacuum inside condenser sucks in plastic film.

A novel and successful method of finding and plugging leaking condenser tubes while the unit is on the line has been developed by operating personnel at the Portsmouth Power Station of Virginia Electric & Power Company, Portsmouth, Virginia. Because this simple method is inexpensive, accurate, and timesaving, it will be of interest to every engineer.

The necessity of a complete shut down to detect a condenser tube leak has now been eliminated and it is possible to take out one half of the condenser successfully, find the leak and return to full capacity 60% sooner than ever before. The key is a plastic film leak detector.

When a tube leak becomes apparent, the condenser is "shot" with sawdust until the leak becomes too difficult to control. At this point the necessary drop in load is scheduled to remove one half of the condenser. Then the condenser is backwashed before taking it off the line to make the leak reappear.

After the circulating water has drained from the leaking half, three operators go into one end of the condenser and cover the entire tube sheet with plastic film. This is most desirable while the sheets are wet. When one end is completely covered, the process is repeated at the other end of the condenser. As vacuum is built up in the leaking tube, the plastic is pulled into that tube showing immediately which tubes are the "culprits." This method has been used many times, returning the condenser to service with one or more tubes plugged and as yet no leak has gone undetected.

Virginia Electric & Power Company's plastic film "leak-detector" method is an ingenious contribution to condenser and heat exchanger maintenance. It is one of many ideas that Bridgeport Brass has brought to the attention of engineers to insure better, more efficient, more economical operation.

Your Bridgeport Salesman — backed by Bridgeport's Technical Service Staff — is continually in contact with the most recent developments in your field. He is always ready to assist you in problems involving the selection, application and use of condenser and heat exchanger tubes. Call him today.

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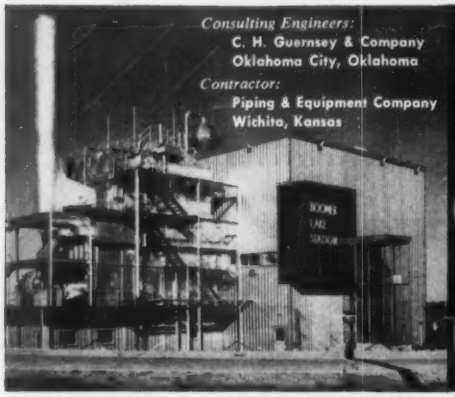
POSITIVE CONTROL OF MATERIALS IN MOTION B-I-F METERS FEEDERS CONTROLS

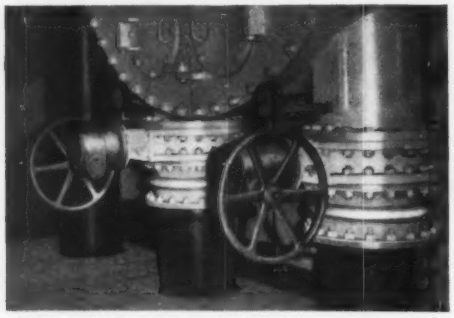


BOOMER LAKE POWER STATION
STILLWATER, OKLAHOMA
USES
B-I-F Builders - Providence
BUTTERFLY VALVES

Modern municipal power plant at Stillwater, Oklahoma, the Boomer Lake Station is designed for maximum efficiency.

FOR

- Condenser shut-off service
- Circulating water

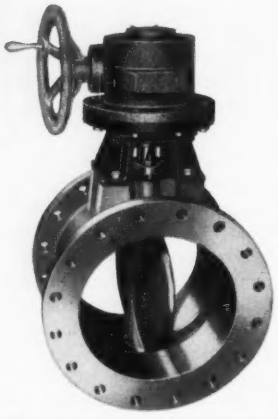


Bubble-tight operation at all times assured by Builders Valves installed at base of condenser.

BECAUSE OF

- Space-saving design . . . permits compact piping layouts; cuts installation costs!
- Bubble-tight shut-off . . . eliminates all leakage!
- Trouble-free, easy operation . . . assures reliable, instantaneous flow control after long time in position!

Three compact Builders Butterfly Valves provide positive control at discharge of circulating water pumps.



REQUEST COMPLETE DATA! Free Bulletin 650-R2 fully describes design features. Write **B-I-F Industries, Inc., Industrial Sales, 354 Harris Ave., Providence 1, Rhode Island.**

B-I-F INDUSTRIES
BUILDERS-PROVIDENCE · PROPORTIONEERS · OMEGA

Technical briefs

Begins on page 110

drops from over 26% to about 23%.

Compressed air is the starting force. A tank charged to 50 atmospheres blows air into the compressor through six injectors which draw atmospheric air into the set along with the compressed air. Pressure in the tank drops to 10 atmospheres while supplying 10% of the air flow needed for starting. The entire starting procedure is automatic.

Phase compensation is one duty of the generator since the turbine-generator set is applied as a terminal station in the power network. Turbine is connected with or cut loose from the generator during this duty by a disk clutch with Ferodo-lined friction disks.

Regulator system is completely electrical up to the actuating devices. Controlling, limiting and feedback functions are reproduced by d-c voltages generated in pickups and amplifiers with small internal resistance. *This paper is not available for general distribution*

TO OBTAIN COMPLETE TEXT

Material for these abstracts comes from the following sources. Order complete paper from the source, not POWER.

American Society of Mechanical Engineers (ASME). Obtainable through ASME, 29 W 39th St, New York 18, New York.

American Institute of Electrical Engineers (AIEE). Obtainable from AIEE, 33 W 39th St, New York 18, New York.

Engineers' Society of Western Pennsylvania, Penn - Sheraton Hotel, Pittsburgh 30, Pa. Papers will be available as part of the Proceedings *of the 19th Annual Water Conference.*

American Power Conference (APC). Papers will be published in book form, obtainable from Illinois Institute of Technology, Technology Center, Chicago 16, Ill.

Wise Owl Club of America is composed of workers who can report eye injuries that *didn't* happen. All saved sight by use of protective glasses.

YOU CAN'T BUY A MARLEY CLASS 600 DOUBLE-FLOW *that won't meet performance*

Full-performance towers are as ethically fundamental as "twelve bananas to the dozen." That is why Marley zealously conforms to this single standard: "You can't buy a Marley Class 600 Cross-Flow that won't meet performance."

That is why an important part of every Marley Class 600 Double-Flow or Single-Flow proposal reads: "Every purchaser is urged to make thermal performance tests of his Marley tower." Each year more cooling tower buyers are including test provisions in their specifications as the one possible method of determining satisfactory performance—of mutual importance to buyer and builder.

Backed by 20 years of Cross-Flow performance research, Marley has complete confidence in its selections for any duty, so customers are given all necessary assistance to facilitate testing by whatever standard is selected. Tests conducted by Marley engineers are scheduled promptly and must receive customer's full concurrence.

Marley welcomes tower tests as an opportunity to present the quality of Class 600 towers to industrial purchasers by publishing annually the consecutive results of the year's testing program. ALL test results are made public—none are deleted.

During 1958, 22 tests were conducted. Of these, 18 indicated capacity in excess of specification. Four tests were deficient, the greatest deficiency being [illegible] of cold water temperature specified. The Marley guarantee provides that these four towers be modified to deliver full performance without added cost to the owner.

Your Marley sales engineer will be glad to supply you copies of test results; also Marley's brochures "Test Your Tower" and "Analyze Your Bids". If more convenient, request them from us.

MARLEY

The Marley Company

Kansas City, Missouri

For more facts circle 263 on Reader Service card, p 125

predictable, dependable performance...

Republic ELECTRUNITE Boiler Tubing offers Quality you can measure

Predictable, dependable Republic ELECTRUNITE® Boiler Tubes were used in the installation of a new power plant unit for the production of electricity for the Borough of Lansdale, Pennsylvania.

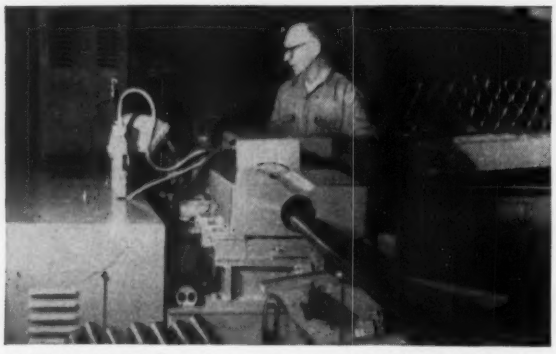
This new steam generator, engineered, manufactured, and erected by Riley Stoker Corporation, Worcester, Massachusetts, is designed to operate at 150,000 pounds of steam per hour, 1000 psi, at a steam temperature of 900° F.

Predictable . . . because ELECTRUNITE Boiler Tubing is hydrostatically or electronically tested to conform with the applicable ASTM specifications and the ASME Boiler and Pressure Code, as well as local, state, and boiler insurance requirements.

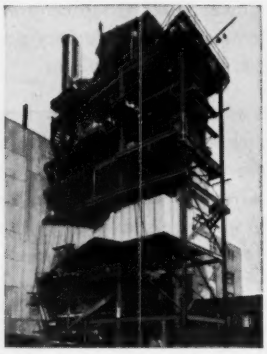
Dependable . . . because ELECTRUNITE Boiler Tubes are made from high-grade steel, produced in Republic's own mills. Operations, materials, and methods are carefully controlled from the time the ore is mined, through mill, and manufacturing processes.

Performance . . . proved on the job, job-after-job. Skilled craftsmen on the job report, "with ELECTRUNITE, the rolling goes well . . . the metal works properly, rolls in smoothly . . . we never worry about cracks in the tubing."

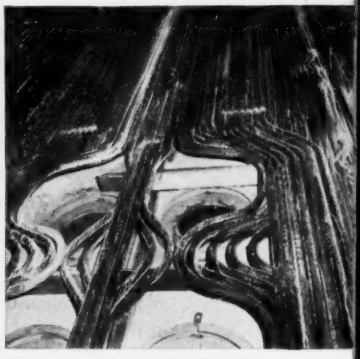
Get the facts. Learn more about Republic ELECTRUNITE for boiler, heat exchanger, condenser, evaporator applications. Call your Republic representative. Or, write direct.



FARROWTEST®—QUALITY YOU CAN MEASURE. Not a laboratory theory, not a mere inspection tool, but an exclusive production test that detects and rejects tubing containing defects of critical size. FARROWTEST is offered as an alternative to other less positive tests in accordance with table below, at no extra cost.



Power plant at Borough of Lansdale does not have a grate surface. Instead, powdered coal fuel which burns in suspension is fed in through water-cooled ports on front wall.

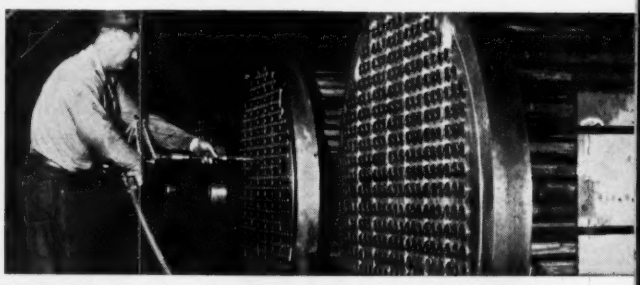


Full normalizing makes Republic ELECTRUNITE uniformly ductile for smooth, easy bending, trouble-free service. This view shows the fuel ports from the inside.

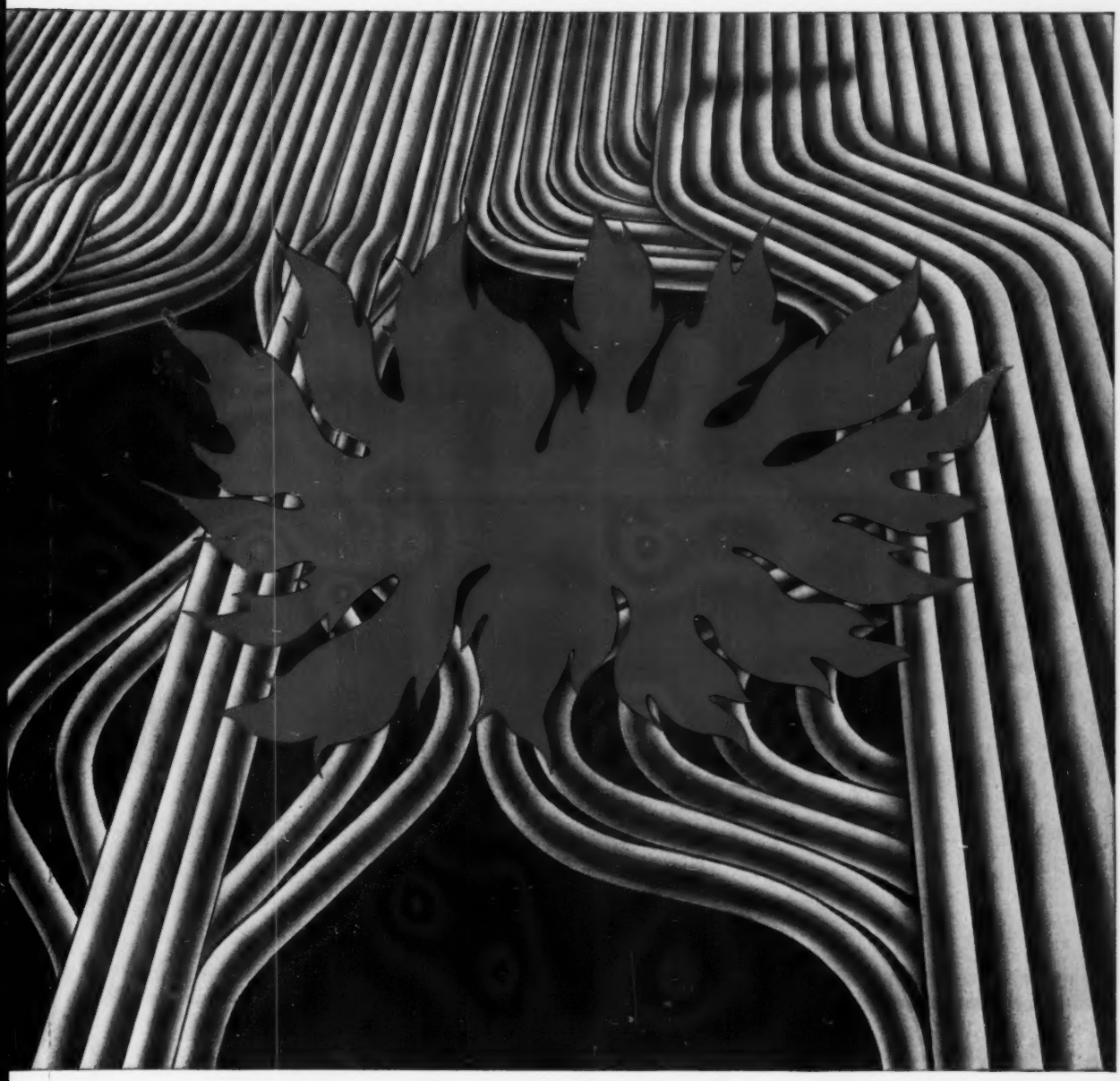
FARROWTEST REJECT TABLE

Wall Thickness (B.W. Gage)	Minor dimension of the defect (Length or Depth)	Defective Area (Length X Depth Plane)
20	.006"	.0025 sq. inches
18	.006"	.003 sq. inches
16	12½% of wall	.003 sq. inches
14 and 13	12½% of wall	.004 sq. inches
12 and heavier	12½% of wall	.005 sq. inches

FARROWTEST detects and rejects not only tubing containing defects which completely penetrate the wall; but also tubing with defects equal to, or greater than, those shown in this table. For irregular defect shapes, a tube with defect area equal to or greater than shown above is rejectable. Where required, sensitivity of FARROWTEST equipment can be calibrated to reject defects of lesser specified area than shown in table, at extra cost.



More and more engineers in utility companies are considering Republic ELECTRUNITE Stainless Steel Tubing for main surface condensers. Republic's ELECTRUNITE Stainless Steel resists corrosion, provides long, trouble-free service where water is used directly from natural sources. Call your local Republic ELECTRUNITE representative, or write for facts and data.



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☐ Republic ELECTRUNITE Heat Exchanger Tubes
☐ Carbon ☐ Stainless ☐ FARROWTEST Brochure

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Firm_____
Address_____
City_____ Zone____ State_____

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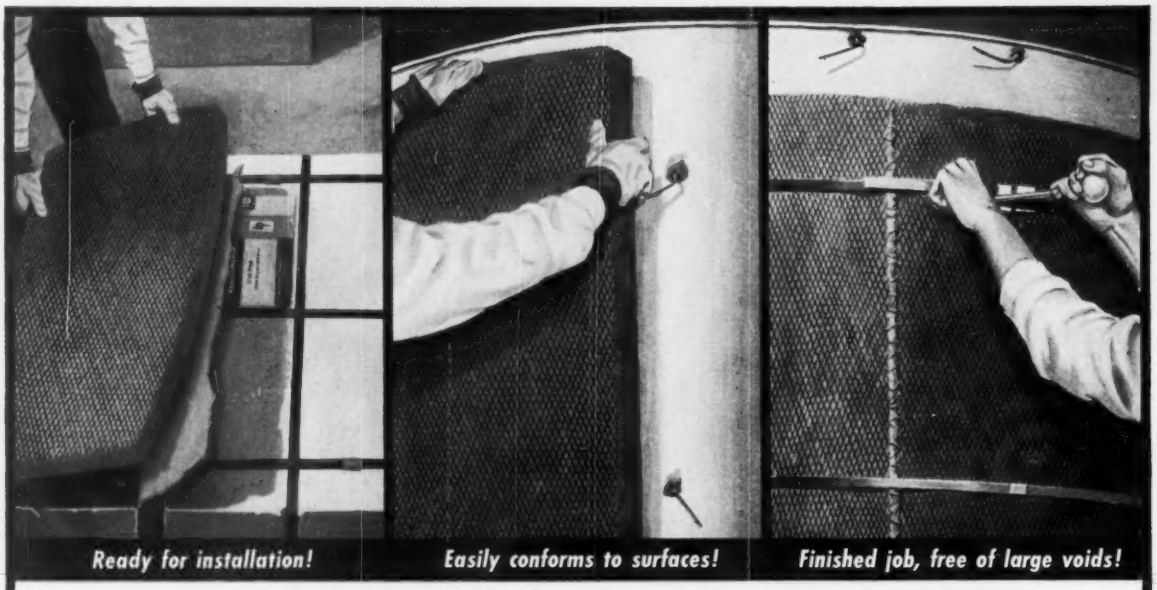
FACTORY FABRICATED TO RIGID SPECIFICATIONS!

EAGLE-PICHER BLANKET INSULATION



Ready for installation! *Easily conforms to surfaces!* *Finished job, free of large voids!*

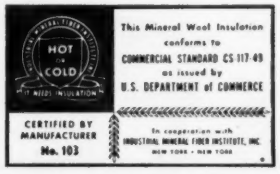
- Copper bearing steel laths, bound by uniformly spaced soft-drawn galvanized tie wires, keep blankets firm but flexible.
- Eagle-Picher mineral wool evenly dispersed over entire insulating area of each blanket.
- Completely free of large voids usually found in field-made blankets where insulation is simply packed in place.
- Smooth edges butted tightly together eliminate cracks and loose joints.
- Quickly applied to flat or slightly curved surfaces of any large equipment—or cut to fit irregular areas.
- Maximum thermal efficiency at temperatures as high as 1200 F.

Eagle-Picher produces a complete line of industrial insulations for all temperatures from below Zero to over 2000 F.

FREE SAMPLE!

Write today!

Eagle-Picher Blanket Insulation conforms to Commercial Standard CS-117-49.



Since 1843

EAGLE EP PICHER

EAGLE-PICHER

The Eagle-Picher Company • General Offices: Cincinnati 1, Ohio

(Member of Industrial Mineral Fiber Institute)

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POWER
SPEED
COMPACTNESS

Fisher-Continental Type 480 will give you all 3 on your next

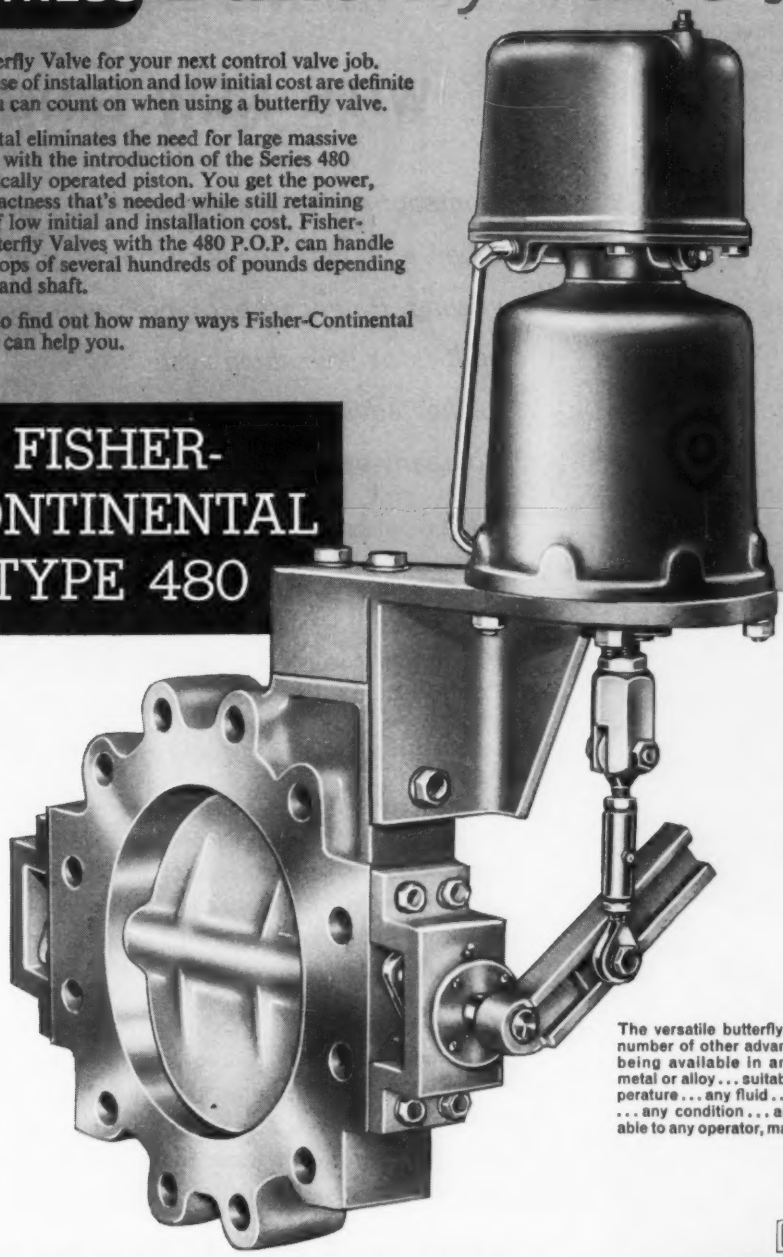
Butterfly Valve Job

Consider a Butterfly Valve for your next control valve job. Compactness, ease of installation and low initial cost are definite plus features you can count on when using a butterfly valve.

Fisher-Continental eliminates the need for large massive power actuators with the introduction of the Series 480 P.O.P. pneumatically operated piston. You get the power, speed and compactness that's needed while still retaining the advantage of low initial and installation cost. Fisher-Continental Butterfly Valves with the 480 P.O.P. can handle high pressure drops of several hundreds of pounds depending on size of body and shaft.

It will pay you to find out how many ways Fisher-Continental Butterfly Valves can help you.

FISHER-
CONTINENTAL
TYPE 480



The versatile butterfly valve offers a number of other advantages such as being available in any size... any metal or alloy... suitable for any temperature... any fluid... any pressure ... any condition... and it is adaptable to any operator, manual or power.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD...CHANCES ARE IT'S CONTROLLED BY...

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / London, England

BUTTERFLY VALVE DIVISION: CONTINENTAL EQUIPMENT CO., CORAOPOLIS, PENNSYLVANIA

CONTINENTAL

FISHER® Controls

SINCE 1880

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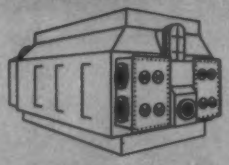
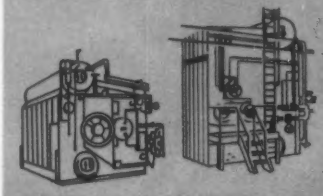
Power Plant Products

HEAT ENGINEERED BY FW

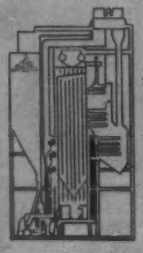


CONDENSERS and HEATERS—Condensers custom designed for individual plant requirements. All-welded high and low pressure feedwater heaters.

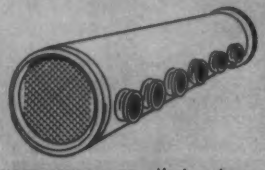


PACKAGED and FIELD-ERECTED BOILERS—Compact, economical, standardized units in capacities from 10,000 to 450,000 lb/hr oil, gas or pulverized coal fired.

LARGE STEAM GENERATORS—Designed to meet all requirements for Central Station or Industrial power plants, in single- or twin-furnace designs, with or without reheat or dual circulation.



COOLING TOWERS—Induced draft counter flow towers of all-redwood construction for maximum dependability and long service.



NUCLEAR COMPONENTS—Heat exchangers, steam generators, pressurizers, reactor vessels, separately-fired superheaters for stationary and marine power plants.

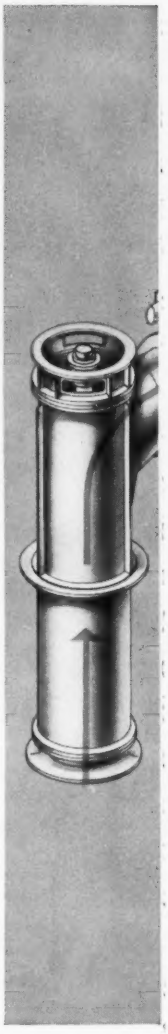
PULVERIZED FUEL SYSTEMS—Completely engineered systems utilizing FW ball mill or MB planetary roll and table pulverizers.

HEAT ENGINEERING

SIMPLIFIES LAYOUT and

WITH NEW SINGLE-PASS,

Compact shells use economical short tubes, eliminate two waterboxes, simplify valving. Balanced back pressure and built-in backwashing system offer further advantages for Alabama Power Company's Barry Steam Plant, Unit No. 3.



Problem: Alabama Power Company and Southern Services, Inc., Engineers, specified that the dual exhausts of the 225,000 kw turbine be handled with condenser tubes at right angles to the turbine shafts —in the tight confines of a plant extension for Barry Steam Plant, Unit No. 3.

Solution: Heat Engineering by Foster Wheeler

By application of the established principles of Foster Wheeler condenser design, a most economical arrangement for a twin bottom-exhaust turbo-generator set with tubes at right angles to the turbine shafts was provided. It features short tube lengths, complete backwashing and a minimum number of waterboxes for a twin-shell design.

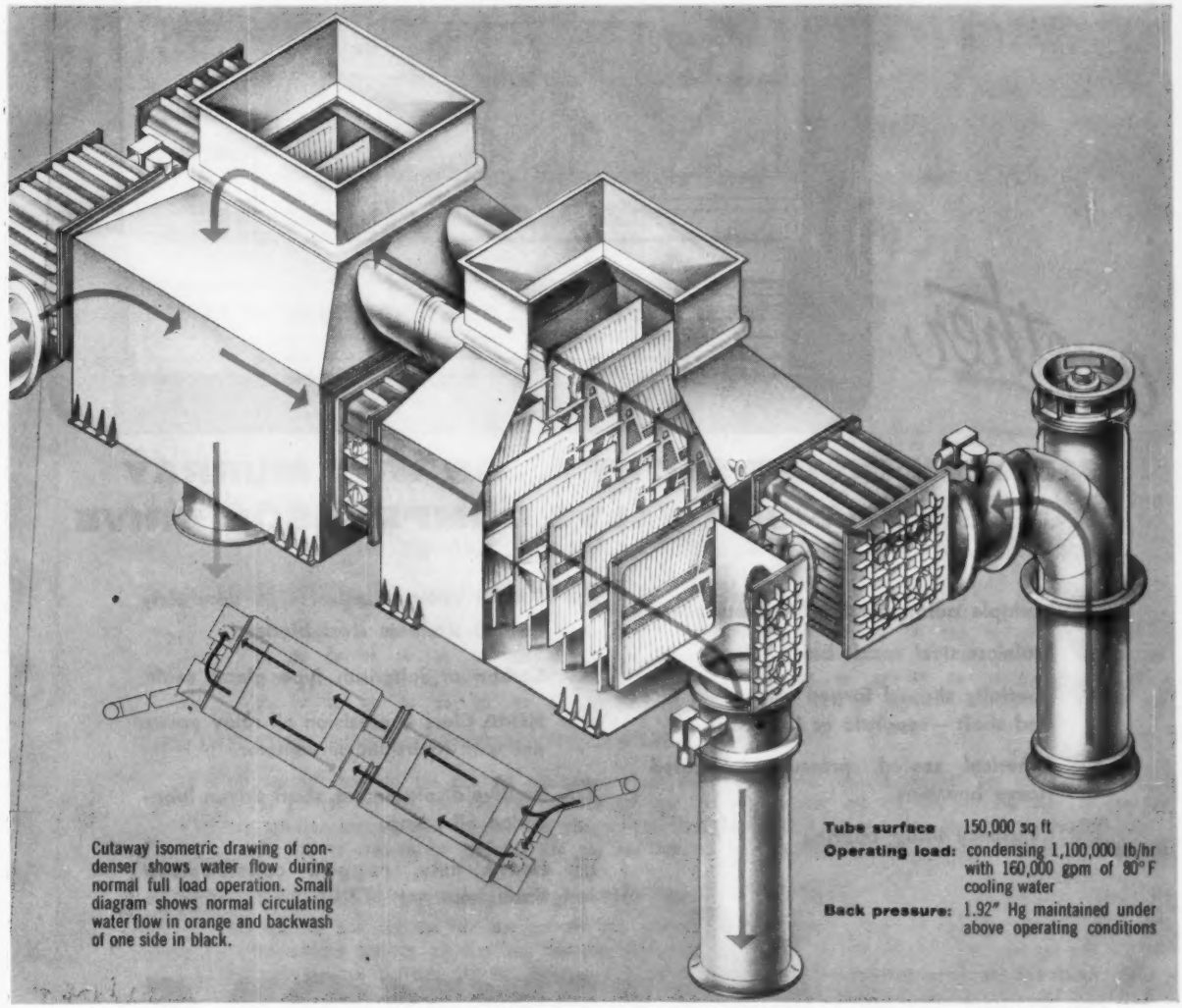
Backwashing of the tube sheets is obtained with only six valves, two of which are the normal circulating pump shut-off valves. This valving arrangement also allows the complete condenser to be operated at light loads with only one circulating pump.

In design advances such as this, you see Heat Engineering at work. This is the concept you can expect—combining new and original ideas with proved engineering principles—when Foster Wheeler serves you. *Foster Wheeler Corporation, 666 Fifth Avenue, New York 19, New York.*

BY FOSTER WHEELER

REDUCES CONDENSER COSTS

COUNTER-FLOW DESIGN



Cutaway isometric drawing of condenser shows water flow during normal full load operation. Small diagram shows normal circulating water flow in orange and backwash of one side in black.

Tube surface 150,000 sq ft

Operating load: condensing 1,100,000 lb/hr with 160,000 gpm of 80° F cooling water

Back pressure: 1.92" Hg maintained under above operating conditions

FOSTER WHEELER

NEW YORK • LONDON • PARIS • ST. CATHARINES, ONT.

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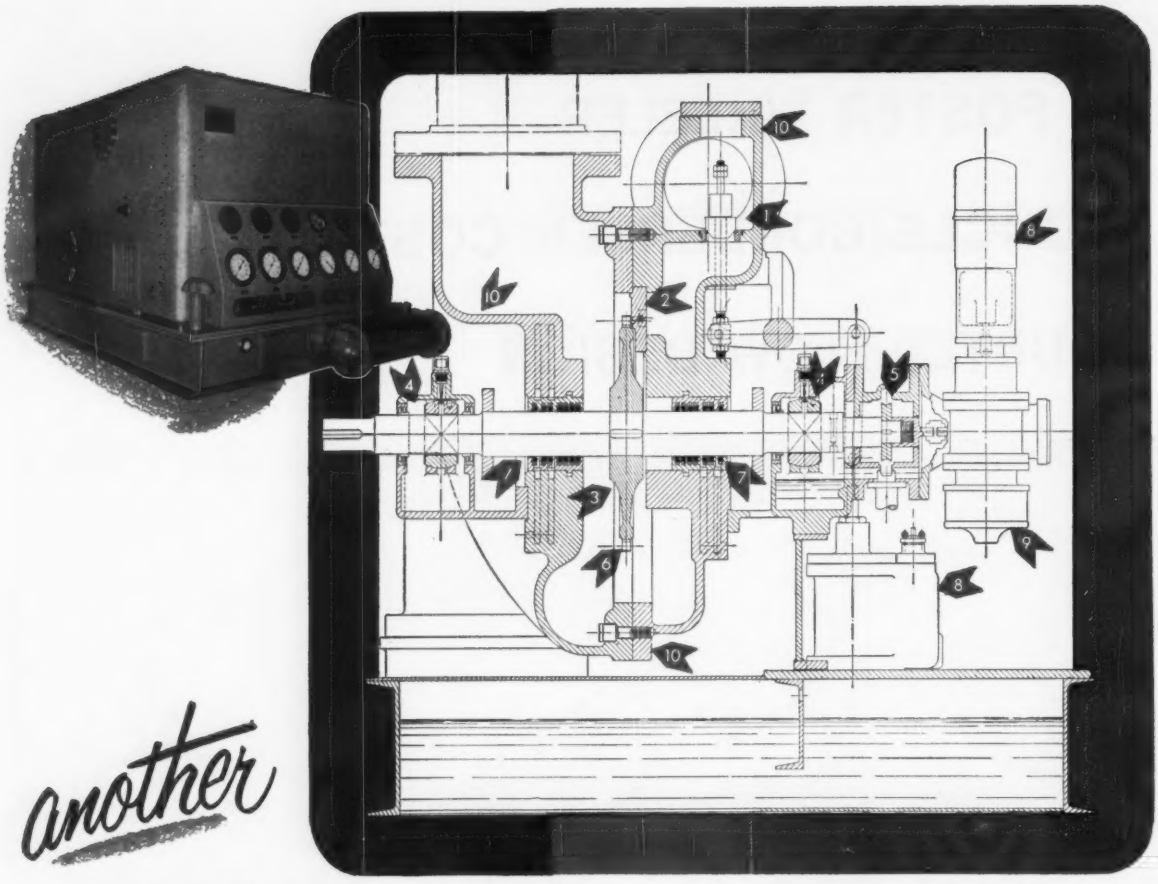

another

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1. Multiple automatic bar-lift inlet valves.
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5. Kingsbury thrust bearing.
6. Special integral spacer type accurately formed stainless steel blades.
7. Carbon or labyrinth type gland seals.
8. NEMA Class D precision oil relay governor with hydraulic servomotor.
9. Positive displacement, shaft driven lubrication oil pump.
10. Heavy duty, rugged construction throughout.

Our nearest representative will help you solve your turbine requirements. His name gladly sent on request.

Murray
TURBINES

MURRAY IRON WORKS COMPANY • BURLINGTON, IOWA

Builders of Steam Power Equipment for Nearly a Century

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Either of the no-postage reader service cards below and p 127 will bring you information on any new equipment listed or product advertised, plus new literature for your files

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- **Read advertisements** and note number listed under each ad. Circle ad numbers on card for complete details.

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PLANT EQUIPMENT in the news this month, starting on p 138

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75
76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

NEW LITERATURE listed in this issue, starting on p 126

101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125
126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150
151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175
176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200

ADVERTISED PRODUCTS appearing throughout the issue

201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225
226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250
251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275
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New free literature

WATER TREATMENT

101 **Packaged deaerators** for small and medium-sized boiler plants are topic of 4-p booklet 4528. The Permutit Co

102 **Jet-tray deaerators** are subject of 4-p bulletins 201, 202, 301, 302, covering left and right-hand mono- and duo-pack units. Kittredge Engineering Company

103 **Stainless-steel deaerators** are discussed in 4-p bulletin 101—specs, diagrams included. Kittredge Engineering Company

104 **Condensate filtration** is topic of 8-p technical reprint T-172. Paper describes supercritical, nuclear and monotube-boiler installations. Graver Water Conditioning Co

105 **Water, sewage** and industrial waste-treatment equipment is listed in catalog 952. Drawings, charts and installation photos illustrate water and bar screens, collectors, settling tanks. The Jeffrey Manufacturing Company

106 **Mixed-bed deioniser** for lab and industrial use is topic of 2-p data sheet 513. Unit delivers up to 120 gph; resin bed is factory regenerated. Elgin Softener Corp

AIR CONDITIONING AND VENTILATION

107 **Induced-draft fans** are described in 16-p bulletin L-8. Fully dimensioned drawings, rating charts and specs give details. Fuller Co, Lehigh Fan & Blower Div

108 **Cyclone dust collector** is discussed in 20-p bulletin 272B. Application, principles, design, construction, operation is covered—a ten-page section describes hoppers, precleaners, aftercleaners. American Air Filter Company, Inc

109 **Air filtering,** cooling, heating, cleaning, moving, exhausting, humidifying and dehumidifying are described in product bulletin 518. American Air Filter Company, Inc

110 **Dust and fume control** systems are covered in 52-p catalog. Wet, dry, electrical and centrifugal collection are shown, plant installations described for various industries. The Kirk & Blum Manufacturing Company

COMPRESSORS

111 **Heavy-duty compressors,** horizontal water-cooled single-stage units, are illustrated in 8-p bulletin 350. Pennsylvania Pump and Compressor Company

112 **Portable rotary compressor,** 250 cfm model, is described in 4-p bulletin 2931. Ingersoll-Rand Co

MATERIALS HANDLING

113 **Belt conveyors** are topic of 88-p catalog ID-591. Photos, diagrams, tables describe heavy-duty and standard roller bearing and precision ball-bearing idlers. Continental Gin Company, Industrial Div, Materials Handling Dept

114 **Materials-handling** equipment—vibrators, car shakers, flow-control valves—is included in 68-p condensed catalog 591. Syntron Company

ELECTRICAL GENERATION AND TRANSFORMATION

115 **Electric generating plants,** 20-kw models, and accessories are subject of 2-p bulletin. Jeta, Inc

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116 **Distribution transformers** are detailed in 28-p catalog 500. Technical specs, design and operating data are given on the dry type single and 3-phase units. Hill Transformer Co, Inc

117 **Transformers,** open dry type, are described in 8-p bulletin GEA-6668A. Units have inorganic insulation. General Electric Company

118 **Transformers,** phase-isolated load tap changing units, are covered in 20-p booklet. Design and construction details, applications and advantages are given. McGraw-Edison Company, Pennsylvania Transformer Div

ELECTRICAL DISTRIBUTION

119 **Conduit and fittings** are described in 60-p handbook and catalog 485. Installations, applications are shown for galvanized conduit and electrical metallic tubing. Technical section includes specs, standard symbols and abbreviations, applicable electrical data. The National Supply Company

120 **Conduletes** for corrosive locations are subject of 16-p bulletin 2699. Various metals and finishes used are described. Crouse-Hinds Co

121 **Motor-control** quick selector 20-p chart includes info on ratings, sizes, features. Two pages cover heater tables. The Arrow-Hart & Hegeman Electric Company

ELECTRICAL APPLICATION

122 **All-steel motor reducers** are topic of revised 28-p bulletin 3100. Helical-gear all-motor and integral reducers use NEMA motors from 1 to 75 hp. The Falk Corporation

123 **Remote control** for molded-case circuit breakers is described in 4-p bulletin 5047-1A. Motor-driven electrically operated units can be added to 70 to 800 amp breakers. I-T-E Circuit Breaker Company

124 **Engine starting control** for automatic starting and stopping of engine-driven generating sets is covered in bulletin 653. Automatic Switch Co

125 **Enclosures** for manual starters, incorporating lock-off device, are described and illustrated in bulletin 2510. Square D Company

126 **Manual starters** are topic of 8-p bulletin 11B1. Design, dimensions, ratings and prices are included. Furnas Electric Company

127 **Vertical battery chargers** to save floor space are illustrated in 4-p bulletin 6529. The Electric Storage Battery Co, Exide Industrial Div

128 **Form-wound ac coils** up to 5000 hp are described in 4-p booklet GEA-6556. Manufacturing techniques are described. General Electric Company

129 **Epoxy encapsulation** for rewound motors is described in 8-p booklet. Includes specs, features. Westinghouse Electric Corporation

130 **Electrical insulating materials,** characteristics and application range, are discussed in 12-p booklet GET-2929. General Electric Company

INSTRUMENTATION

131 **pH recorder** composed of electrode assembly and amplifier and potentiometer recorder is described in spec sheets E12-4, E67-5 and -6. Bailey Meter Company

continued

June 1959 issue

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PLANT EQUIPMENT in the news this month, starting on p 138

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75
76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

NEW LITERATURE listed in this issue, starting on p 126

101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125
126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150
151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175
176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200

ADVERTISED PRODUCTS appearing throughout the issue

201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225
226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250
251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275
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326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350
351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375
376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400
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NEW FREE LITERATURE continued.....circle key numbers, page 125, for your copies

132 **Electroluminescent readout lamps** for dials and indicators are topic of 4-p booklet. Westinghouse Electric Corporation, Lamp Div

133 **Power-plant automatic controls** are described in 12-p bulletin E-88. Sensing power loads, starting, regulating and shutting down are covered. The Cooper-Bessemer Corporation

134 **Automatic systems** for sensing, measurement, control are discussed in 6-p folder. Atronic Products Inc, Industrial Equipment Div

135 **Digital voltmeter,** ac and dc model, is described in 2-p data sheet. Cohu Electronics, Inc, Kin Tel Div

136 **Card-punching typewriter** to cut costs is subject of 4-p bulletin RT-3905. Sperry Rand Corporation, Remington Rand Div

137 **Instrument and control switches** are topic of 8-p bulletin 14B8112B. Photos, diagrams show details. Allis-Chalmers Manufacturing Company

138 **Mercury manometer,** multiple electric-contact type, is covered in spec sheet 12D1425. Fischer & Porter Co

139 **Colorimetric analyzer** for automatic determination of water hardness, pH, residual chlorine is described in 2-p bulletin 858. Florida Instrument Company

140 **Liquid level and flow control** is topic of 24-p bulletin ERS-A. Booklet shows how standard products are used to solve various control problems. McDonnell & Miller, Inc

141 **Differential-pressure indicator** is topic of 2-p spec sheet A-109. Aircraft Porous Media, Inc

142 **Relative humidity recorder** is topic of 2-p data sheet ND46-92(1). Leeds & Northrup Company

143 **Controllers,** regulators, recorders, thermometers, pneumatic and electric models, are some instruments listed in 4-p condensed catalog 358. Scientific Instrument Co

144 **Infrared analyzer** is topic of 4-p bulletin 700. Analytic Systems Company

145 **Pneumatic transmitter** for water, sewage and industrial use is covered in 4-p bulletin 285.20A-1. B-I-F Industries, Inc

146 **Liquid-level indicator,** miniature transistorized secondary type, is subject of spec sheet WG-1824. Yarnall-Waring Company

147 **Torquemeters** for measuring dynamic torques on shafts turning at 50 to 12,000 rpm are covered in 2-p spec sheet. Metron Instrument Company

148 **Analyzers** — infrared, photometric, oxygen-trace, thermal-conductivity types—are described and illustrated in new bulletin. Analytic Systems Company

149 **Control meter,** a miniature electronic unit, is topic of 4-p data sheet. Gives full electrical, other specs. International Instruments Inc

150 **Multiconductor cable** for installing 6 to 56 pairs of thermocouple leads at one time is described in 4-p bulletin 33. Thermo Electric Co, Inc

151 **Centralized source** of technical information can cut costs of purchasing test instruments, according to 8-p brochure. Technical Information Corporation

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An informative advertisement from one of the nation's most experienced condenser manufacturers

Steam condenser efficiency depends on water temperature and condition, proper maintenance procedures and many other factors. One of the most important is the design of the condenser itself—and *this* is largely a function of tube sheet design.

Triple Lane Tube Layout, a development of C.H. Wheeler Manufacturing Company of Philadelphia, is making significant contributions to condenser operating efficiencies in public utilities and industrial plants throughout the country. Figure 1 shows a C.H. Wheeler Dual Bank Surface Condenser with Triple Lane Tube Layout.

This tube sheet design permits steam to travel through three separate pathways. As a consequence steam penetrates to all condensing surfaces and utilizes to the fullest extent the condensing capabilities of the steam condenser.

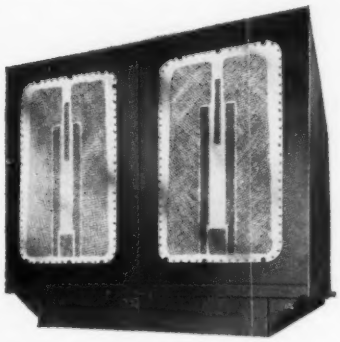

Figure 1: Typical C.H. Wheeler Condenser with Triple Lane Tube Layout.

Central location of the air cooler section, another C.H. Wheeler design feature, also improves steam travel. It reduces the depth of steam penetration and therefore reduces resistance to steam passage, achieving a new low in condenser pressure loss.

How Reverse Flow Improves Condenser Efficiency, Reduces Maintenance

Proper maintenance—keeping tubes and tube sheets free from foreign matter, algae and scale—helps keep condensers operating at peak efficiency. In some cases grass and twigs build up to a point where they would ordinarily have to be shoveled out! It is in such cases that C.H. Wheeler Reverse Flow solves time-consuming, expensive maintenance problems. Here's how it works:

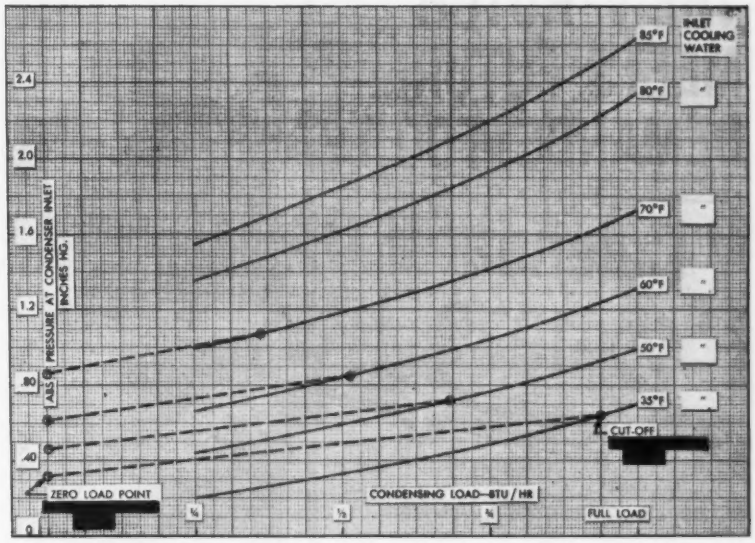

Figure 2: Typical condenser performance curves show how inlet cooling water temperature affects absolute pressure at condenser inlet at varying condensing loads. For a complimentary copy of the 38-page Condenser Handbook from which these curves are taken, write to C.H. Wheeler on your company letterhead.

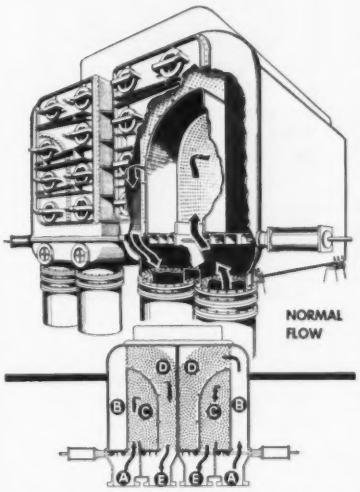

Figure 3: Diagram of C.H. Wheeler Reverse Flow which cleans tubes and sheets during full load operation.

Normal operation is shown on the left in the diagram in Figure 3. Water enters through inlet A with inside port open, flows through tube bank C to the rear of the condenser. It returns through tube bank D to the front of the condenser and discharges at E.

The right side of the diagram in Figure 3 shows Reverse Flow in operation in a C.H. Wheeler Dual Bank, Divided Water Box Condenser. Water enters through A with outside port open, flows up through channel B and through tube bank D to rear of condenser, returns through tube bank C to front of condenser and discharges at E.

Reversing can be accomplished during full load operation and full flow of circulating water, without additional pressure loss. Sluice gates for each half of the condenser move on a common stem. Each half of the condenser can be back-flushed independently; or both halves can be back-flushed simultaneously with one or two circulating pumps operating.

Because of more-than-half-a-century of experience in condenser design and maintenance, C.H. Wheeler is unusually well qualified to advise on condenser efficiency and maintenance problems. We invite your inquiry, whether you're concerned with condensers or with circulating and condensate pumps and other auxiliary equipment. A note on your company letterhead will receive prompt attention from us.

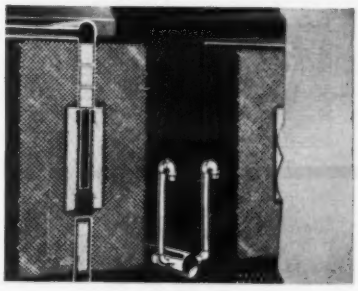

Figure 4: Central location of air cooler section in C.H. Wheeler Condensers reduces depth of steam penetration and therefore lessens resistance to steam passage, achieving a new low in pressure loss in the condenser.

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That's why the V-notch Chlorinator has such tremendous range. The precision shaped groove in a V-notch plug is made to control chlorine completely to one eight-hundredth of the maximum capacity of your machine. In fact, this is standard in some of the V-notch chlorinators.

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Begins on page 126

WELDING

152 **Welding products** and practice are covered in 32-p brochure. Stainless low-alloy nonferrous rods and electrodes for manual, automatic and semiautomatic welding are described. Arcos Corporation

153 **Electrode** for dissimilar - alloy welding is covered in 6-p bulletin. Whitehead Metals, Inc

154 **Welding fittings** for noncritical plumbing, heating and cooling systems are covered in catalog H-1. Nibco, Inc, Steel Div

155 **Centrifugal separators** for purifying and dewatering lube and fuel oils are topic of 8-p bulletin 2141. Estimation charts and tables give capacity ranges for four sizes. Centrico, Inc

156 **Wear-in compound** for breaking in new or rebuilt machinery is topic of 2-p bulletin 120. The Alpha-Molykote Corporation

157 **Automatic desludgers** for fuel and lube oils and other products are discussed in 8-p bulletin 2177. Centrifuges can purify up to 1200 gph of motor testing-stand oil. Centrico, Inc

MAINTENANCE

158 **Metal-filled epoxy cement** use is topic of 4-p bulletin. Illustrations show applications. Smooth - on Manufacturing Company

159 **Dust-collector cleaning** with nontoxic cleanser is described in case-history booklet. The North American Mogul Products Company

160 **Corrosion - resistant coatings** for steel, concrete and wood are listed in bulletin 259. Wisconsin Protective Coating Corp

161 **Scale removal** from water-using equipment is detailed with case histories. The North American Mogul Products Company

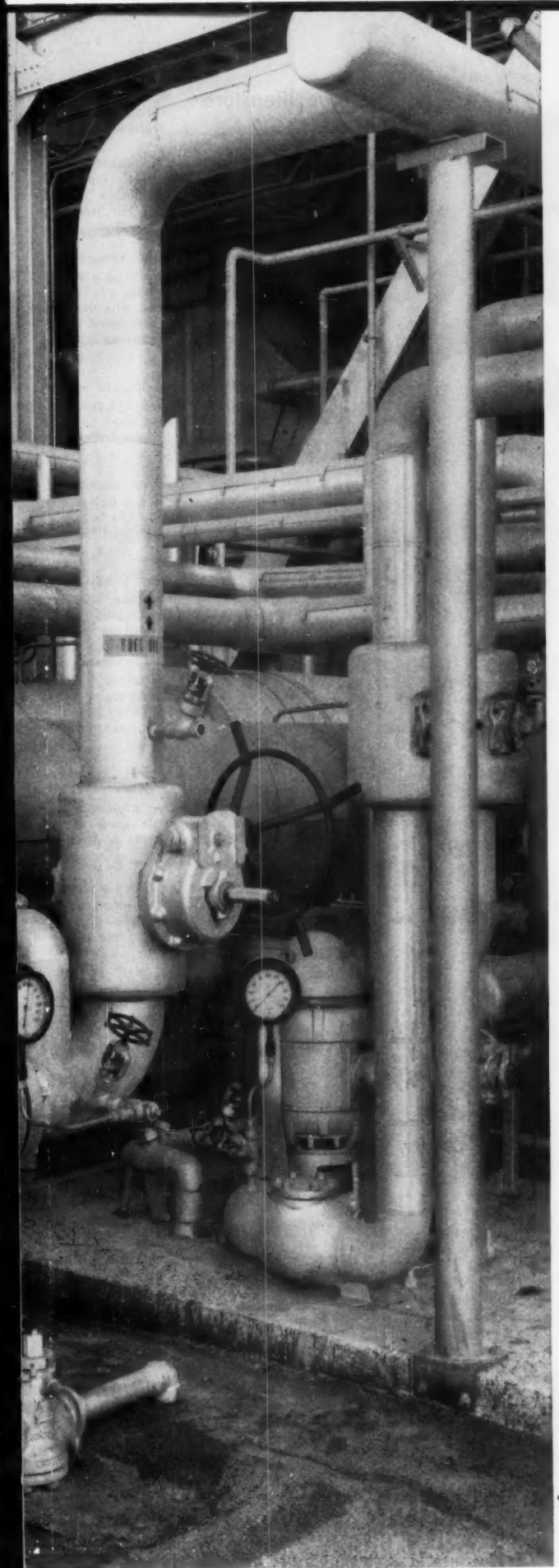
NUCLEAR ENERGY

162 **Nuclear activities** are discussed in 28-p bulletin AEB-8. Company's interests, from design and erection of complete reactors to solution of design parameter problems, are illustrated and described. The Babcock & Wilcox Company, Atomic Energy Div

163 **Problem of safety** with radioactive substances is discussed in issue No. 16 of *Radioactivity at work*. Nuclear Science and Engineering Corporation

MECHANICAL POWER TRANSMISSION

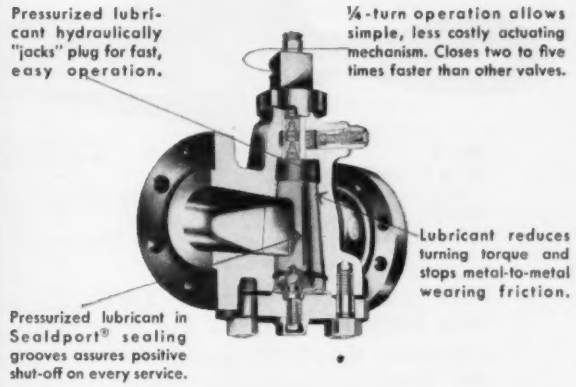
164 **Clutch-pulley package** for direct installation on standard electric



CAN FUEL OIL LINES BE SHUT-OFF FAST AND TIGHT?

It only takes one fuel oil line emergency to dramatically show that most valves close too slowly or fail to shut-off tightly. To *insure* fast, tight shut-off, many power engineers are specifying Rockwell-Nordstrom valves. For some of the logic behind their choice, look at the drawing of the cut-away valve below. Notice that the plug fully opens or closes the valve with just a quarter-turn . . . as opposed to dozens of turns needed to close other valves. And see how the plug is positively sealed by pressurized lubricant (heavy red lines) . . . there are no exposed metal-to-metal seats to wear out, corrode or chatter.

The drawing also shows just a few of many other performance advantages of Rockwell-Nordstrom valves for handling fuel oils . . . or any gas or liquid. The smoothly contoured body has no gaping cavity to collect sediment and perhaps jam the seats. And the heavy red section at the top of the plug illustrates the pressurized lubricant that hydraulically cushions the plug for instant operation whether the valve is opened once an hour or once a year. Lubrication saves money too. It prevents the metal-to-metal wearing friction that can quickly ruin "dry" valves.


Pressurized lubricant hydraulically "jacks" plug for fast, easy operation.
¼-turn operation allows simple, less costly actuating mechanism. Closes two to five times faster than other valves.
Lubricant reduces turning torque and stops metal-to-metal wearing friction.
Pressurized lubricant in Sealdport® sealing grooves assures positive shut-off on every service.

Rockwell-Nordstrom valves, the world's most complete line of lubricated plug valves, cost no more to buy—often less—than ordinary valves. You can get complete details, or have a Rockwell Field Engineer visit you by writing to Rockwell Manufacturing Company, Pittsburgh 8, Pa. Canadian Valve Licensee: Peacock Brothers Limited.

ROCKWELL-Nordstrom VALVES

another fine product by

ROCKWELL

Rockwell-Nordstrom Hypreseal valves, (bottom center uninsulated, center insulated, worm gear operated) on high pressure hot oil lines at large western power station.

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⅛" to 2" Capacity . . . Self-Feeding for Least Effort

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Take your choice—Spiral or "LonGrip"—you can't beat these RIDGID Reamers. For hand reaming, you probably prefer the effortless self-feeding Spiral; for power use, the "LonGrip" five-fluted reamers. Heat-treated cutting edges offer extra-long service . . . will not dig in and thin or flare walls. All RIDGID Ratchet Reamers come equipped with handle.

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For smoother, faster reaming
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Begins on page 126

motors, 1 to 25 hp, is subject of 10-p booklet WEB P-52. Operation, dimensions, selection are covered. Warner Electric Brake & Clutch Company

165 **Screw conveyor drive** complete with speed reducer, packing gland and drive shaft is topic of 16-p bulletin A667C. Photos, engineering drawings and tables give details. Dodge Manufacturing Corporation

166 **Belt-conveyor scales,** control systems are covered in 8-p general catalog 2M. Schematics show typical applications. Trans - Weigh Company

167 **Ball bearings,** maximum capacity units, are discussed in 4-p bulletin 107. Units are designed for heavy radial loads. Hoover Ball and Bearing Company

168 **Fasteners** for open-end V-belting are described in 6-p folder V-227. Belt - length determination, replacement, design pointers are covered. Flexible Steel Lacing Co

169 **Nylon-core belting** is topic of 12-p booklet. History, advantages of the flat transmission belting are given. L H Shingle Company

SAFETY

170 **Types of fires** are listed on 18x24-in. wall chart. Three classes of fires, extinguishers for each are illustrated. Walter Kidde & Company, Inc

171 **Fire-extinguisher guide** is a 6-p folder. Table compares characteristics of various types of fire extinguishers; graph gives effectiveness of extinguishing agents. Ansul Chemical Company, Fire Equipment Div

172 **Safety controls** for oil burners, air conditioners, refrigeration equipment are break-glass switches with solid brass construction—2-pc spec sheet gives details. Automatic Switch Co

STEAM GENERATION

173 **Packaged boilers,** mechanical pressure atomizing oil-fired and partial premixing gas-fired units, are discussed in 8-p bulletin 1250. Orr & Sembower, Inc

174 **Combustion control diagrams** for stoker-fired boilers are included in 4-p bulletin 515. Chain-grate and spreader stokers are covered. Bailey Meter Company

PRIME MOVERS

175 **Horizontal steam turbines** are topic of bulletin 100-1-C. Units are suitable for driving boiler-feed pumps, fans, condenser pumps and generators. Whiton Machine Co

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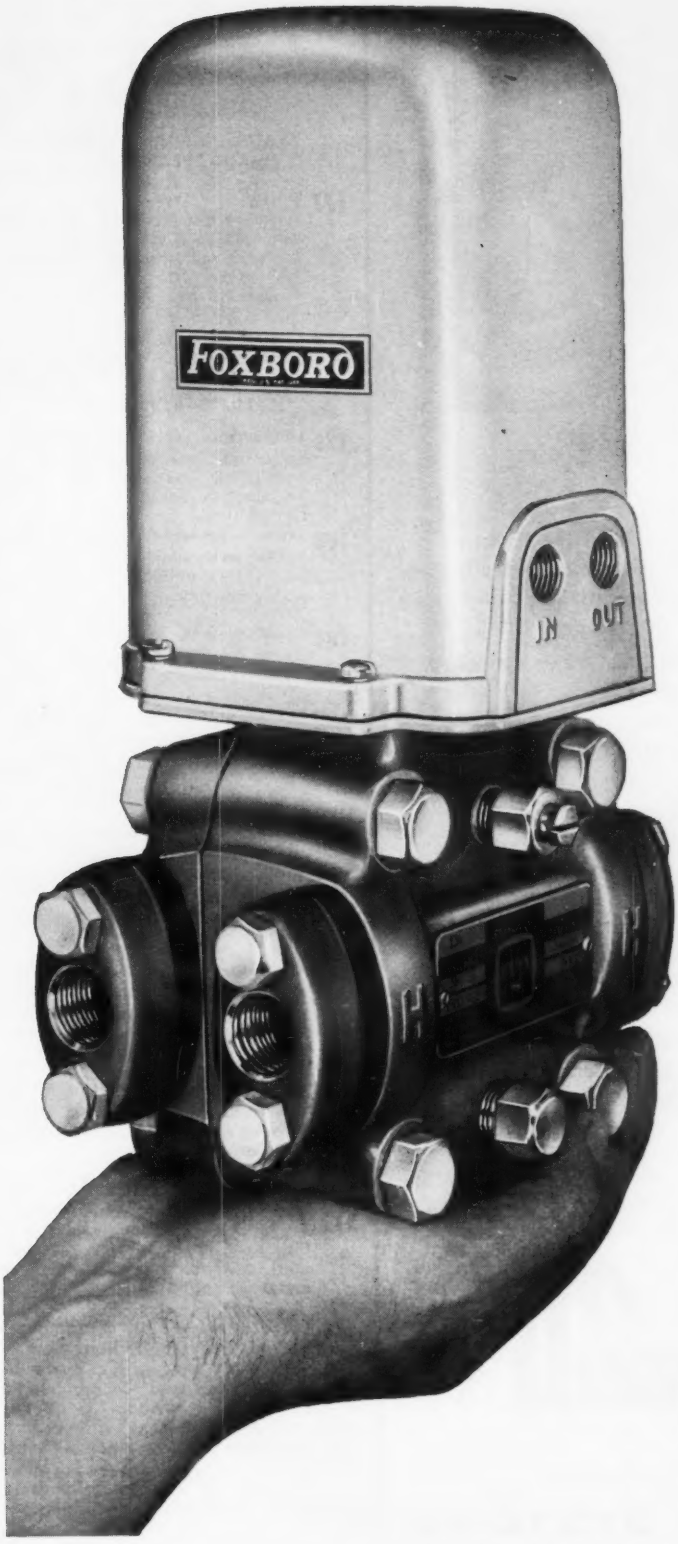
basic tool for process measurements . . .



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Working pressures of 500, 1500, and 6000 psi

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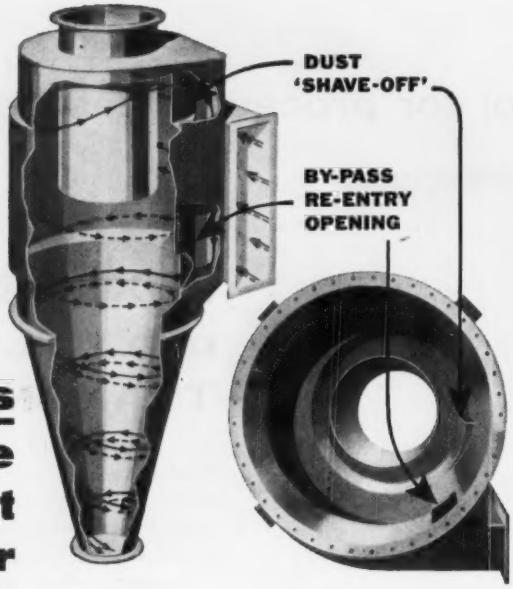

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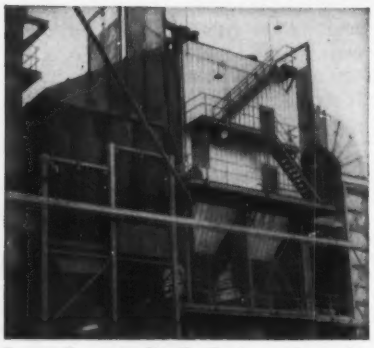
Other features include extra heavy plate construction for longer service life, Buell-designed manifolds for more efficient, non-turbulent flow of dust-laden gases . . . and the confidence assured by a history of hundreds of installations everywhere in America. Write for a copy of the 12-page booklet, "The Exclusive Buell Cyclone": Dept. 50-F, Buell Engineering Company, Inc., 123 William St., New York 38.



Large-diameter Buell Cyclones in series with Buell 'SF' Electric Precipitator.

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DUST COLLECTION SYSTEMS

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Begins on page 126

176 **Diesel engines** producing 340 hp at 2000 rpm turbocharged, 230 hp at 2000 rpm naturally aspirated, are detailed in 16-p bulletin BU 540. Includes photos, cutaways, performance curves. Allis-Chalmers Manufacturing Company, Engine-Material Handling Div

VALVES, PIPING, FITTINGS AND SPECIALTIES

177 **Solenoid valves** of bronze and stainless steel construction are detailed in 36-p catalog 444. Specs, performance data, application info are given. Cutaways illustrate operation. Atkomatic Valve Co

178 **Control valve,** 3- and 4-way model, is discussed in 4-p leaflet 300. Materials, maintenance features are covered. W H Nicholson and Co

179 **Diaphragm valve** for instrumentation and automation use is described in bulletin 259. Versa Products Co, Inc

180 **Steam-pressure-reducing valve** using mechanical pilot operation is topic of bulletin 582. Includes sizing and capacity info. Leslie Co

181 **Check valves,** steel-bodied silent units, are listed in bulletin 110. Combination Pump Valve Co

182 **Sliding-gate valve,** a pilot-operated pressure-reducing unit, is topic of 4-p bulletin J-1160. Includes dimension, capacity tables, cutaways. OPW-Jordan

183 **Tilting-disk check valve** is detailed in 16-p bulletin. Features, specs, engineering and application data are given for cast-iron and steel valves. Dominion Engineering Company Limited

184 **All-molded pvc valves** for corrosion resistance are covered in 6-p folder 601. Advantages, limitations, corrosive-fluid recommendations are given. Lunkenheimer Co

185 **Valves, regulators,** heating valves and controls are listed on 12x18-in. wall chart 59. A W Cash Valve Mfg Corp

186 **Bypass valves** for feedwater heaters, 3-way type, are covered in 4-p bulletin 8F. Sectional drawings and info on design features, materials are included. Schutte and Koerting Company

187 **Valve operator** for actuation of plug valves is described in bulletin 20-58. No gear changes or modifications are needed. R E Lovekin Corporation

188 **Motorized valve operator** for small globe and gate valves, new or installed, is covered in bulletin 21-58. R E Lovekin Corporation

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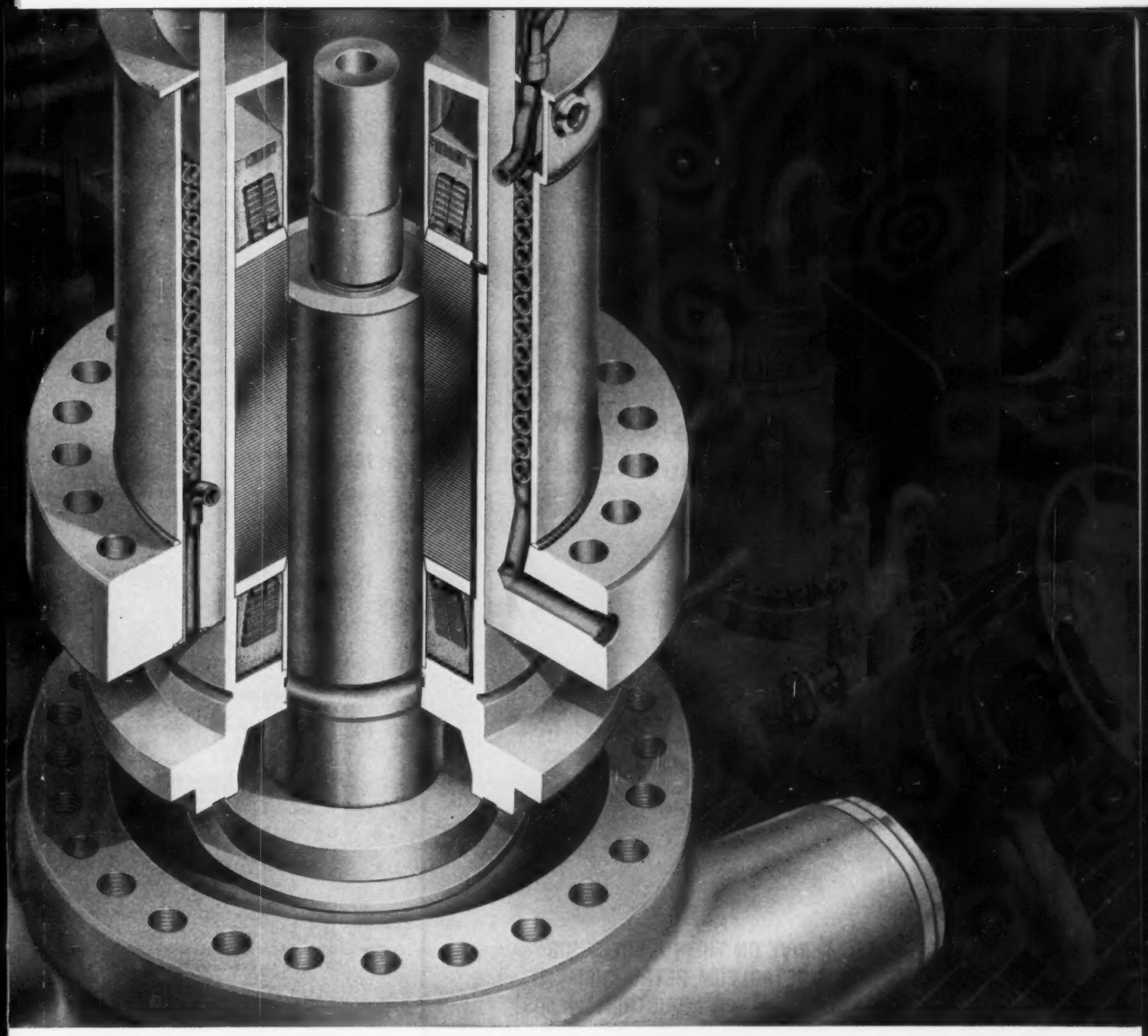

New Removable Stator Design, "Canned" Motor-Pump (exploded cutaway view)

For better boiler circulation...specify Westinghouse "canned" motor-pumps

Controlled circulation boilers equipped with Westinghouse "canned" motor-pumps have a higher unit efficiency, are more reliable and are easier to operate and maintain.

The pump and motor casings completely enclose the pump shafting... Conventional shaft seals and complicated seal injection systems are eliminated.

Watertight Inconel cans encase the rotor and stator . . . All windings are dry and clean for years of trouble-free operation.

New unit construction of stator and rotor permits easy, fast (24-hour), in-your-shop inspection, overhaul and repair... Reliability and availability of pumps are at a maximum.

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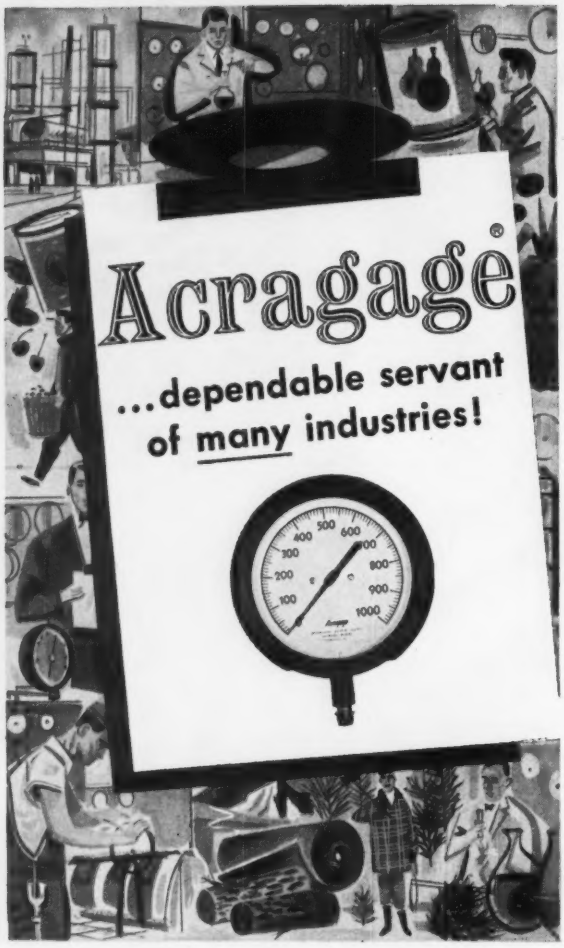
WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV MONDAYS

For more facts circle 275 on Reader Service card, p 125



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ACRAGAGES have achieved a reputation for unsurpassed dependability in a wide range of applications and industries. This reputation is a result of top quality workmanship and outstanding features such as the solid front case with full area rear blowout disc for positive protection, a longer Bourdon Tube, precision movements, and a choice of Tube materials. Acragage can fill your precise requirements with exactly the right gage for the job! Write for more information and latest bulletin!

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Free literature

Begins on page 126

189 **Valves, strainers,** filters, accumulators and other products are listed in 12-p catalog C-591. Valves for cryogenic mixtures are featured. Koehler Aircraft Products Co

190 **Self-cleaning strainers,** automatic and twin-basket models, are covered in 17-p catalog. Units are for removal and continuous disposal of fine suspended particles from raw or process water, other liquids. S P Kinney Engineers, Inc

191 **Spray nozzles** for small to medium quantities are discussed in 20-p booklet AD-148, bulletin 6A-622-2. Photos show distribution patterns delivered by four styles. Schutte and Koerting Company

192 **O ring** design and application is discussed in 20-p booklet AD-148. Construction materials, dynamic and static applications, groove design are covered. The Garlock Packing Company

MISCELLANEOUS

193 **Engineering progress** and achievements of the firm for 1958 are described in 36-p brochure. Allis-Chalmers Manufacturing Company

194 **Equipment leasing** pros and cons for smaller businesses is subject of 16-p study. Complete cost charts are included. Foundation for Management Research

★ EDITOR'S NOTE: *The following bulletins may be requested directly from manufacturer. Write on company letterhead to addresses below*

★ **Analyzers** for colorimetric determinations of trace quantities of substances dissolved in liquid process streams are topic of 8-p bulletin 1156-1. Milton Roy Company, 1300 E Mermaid Lane, Philadelphia 18, Pa.

★ **Heat exchangers,** double-pipe or hairpin type, are subject of specifications manual M-100. Design, materials, welding procedure, testing and inspection are included. Brown Fintube Company, 510 Huron St, Elyria, Ohio

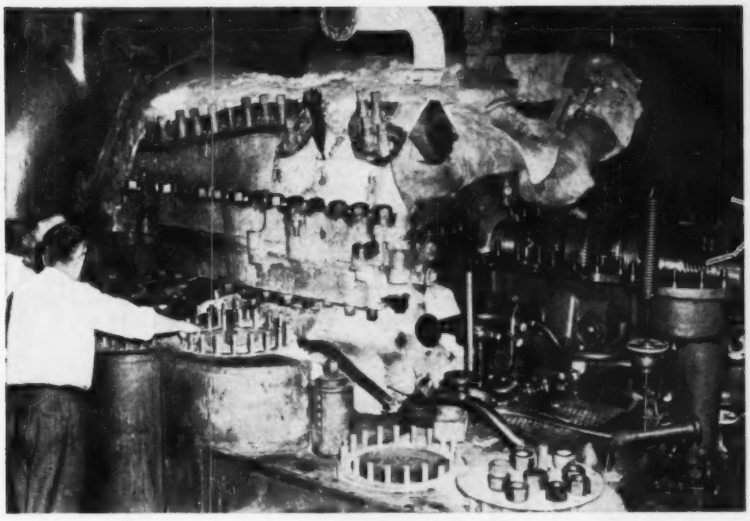
★ **Potentiometer specs,** diagrams, general info are included in 28-p technical catalog. DeJur-Amsco Corporation, Electronic Sales Div, 45-01 Northern Blvd, Long Island City 1, N. Y.

India is getting help in maintaining her power plants through the U. S. Mutual Security Program. M L Bosch of Topeka, Kansas, a hot-line maintenance expert, is teaching Indian engineers how to avoid shutdowns.

MOLYKOTE® LUBRICANT POWER NEWS

PRACTICALLY 100% PROTECTION AGAINST THE GALLING AND SEIZING OF ALL HIGH TEMPERATURE THREADED CONNECTIONS

MOLYKOTE TYPE G IS BEST THREAD LUBRICANT AVAILABLE



Hundreds of threaded connections in a turbine are subjected to temperatures which may go as high as 1100°F.

Every power engineer realizes that the extreme bearing pressure in a threaded connection is carried at a series of contact points on the mating surfaces of the threads. The number of these contact points increases with load. Since these contact points are not spaced symmetrically about the thread circumference, off-center loads increase the severity of the contact pressures and frictional conditions.

Liquid lubricants are ineffective under these load conditions and seizing and galling often occur when make-up or break-away torque is applied.

MOLYKOTE exhibits the lowest coefficient of friction of all solids at extreme bearing pressures and offers the highest resistance against galling and seizing. Because of its strong affinity for attachment to metal, it cannot be wiped off. MOLYKOTE used in threaded connections remains effective at temperatures in excess of 1100°F. The saving in damage to threaded connections in the power industry runs into fantastic figures.

When writing, refer to Item 510

LEADING POWER EQUIPMENT MANUFACTURERS SPECIFY MOLYKOTE FOR MACHINERY WEAR-IN

Leading power equipment builders have found after years of experience that the use of MOLYKOTE Lubricants is their best guarantee against breaking-in damage. Costly service calls to refinish damaged parts have been eliminated. During reassembly, after overhaul, MOLYKOTE WEAR-IN COMPOUND provides the same basic guarantee of dependable service.

When writing, refer to Item 511

REPRINT AVAILABLE

"SOLID LUBRICANTS . . ." *an 8-page reprint from the Nov. 1958 issue of POWER, is available until supply is exhausted.*

MOLYKOTE TYPE Z UNAFFECTED BY RADIATION

Used in Critical Areas of Latest Nuclear Power Plants for Lifetime Lubrication

The nuclear power plant has complicated lubrication problems. Not only must lubricants operate over a wide temperature range, but they must be unaffected by radiation and, in many cases, must provide lifetime lubrication because of the inaccessibility of parts and the danger involved in servicing reactors.

More than a decade ago, scientists working for the Atomic Energy Commission discovered that MOLYKOTE Type Z was unaffected by radiation and they used it to lubricate equipment subjected to intense radiation. During the development and testing of nuclear power plants for atomic submarines, MOLYKOTE Type Z was specified by the designers and used extensively.

Today, more than ever, with the development of atomic reactors for the power industry, more emphasis is being placed upon the vital quality of lifetime lubrication and MOLYKOTE is being called upon to play a part which is continually increasing in importance.

When writing, refer to Item 509

MOLYKOTE TYPE Z REDUCES SERVICING OF EQUIPMENT

MOLYKOTE Type Z powder is being used on timing devices, Variacs, rheostats, knife switches and circuit breakers where conventional lubricants gather dust or tend to become gummy.

In many applications it has been noticed that pitting and oxidation of contact points was considerably reduced after MOLYKOTE Type Z was applied. Countless man-hours are saved in cleaning, adjusting and lubricating electrical contacts and relays.

When writing, refer to Item 512

Address your letter to The Alpha-Molykote Corp., 65 Harvard Ave., Stamford, Conn.
Phone: FIreside 8-3724.

SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE

THE ALPHA-MOLYKOTE CORP.
Stamford, Connecticut
Please send me details on

Item 509 ☐ **Item 510** ☐ **Item 511** ☐ **Item 512** ☐

Name _____
Company _____
Address _____
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THE ALPHA-MOLYKOTE CORPORATION

BREAKING LUBRICATION BARRIERS . . . THROUGH RESEARCH

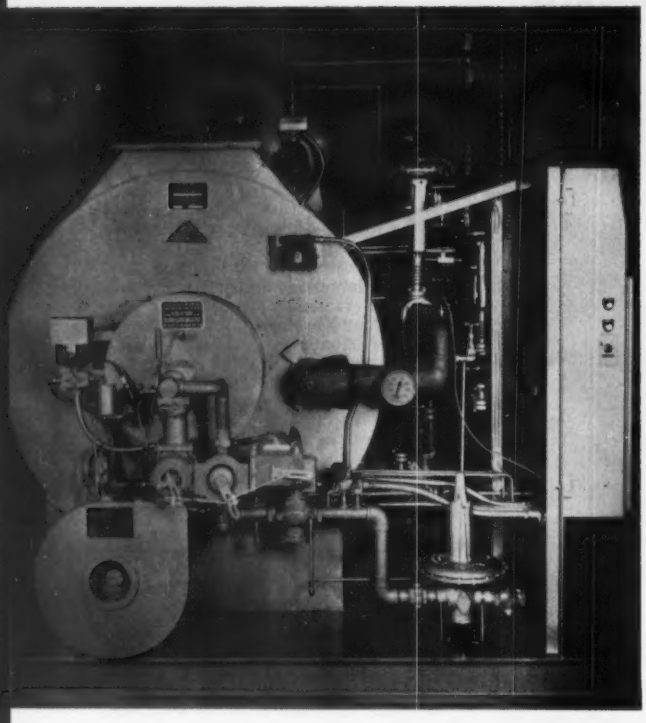
For more facts circle 277 on Reader Service card, p 125

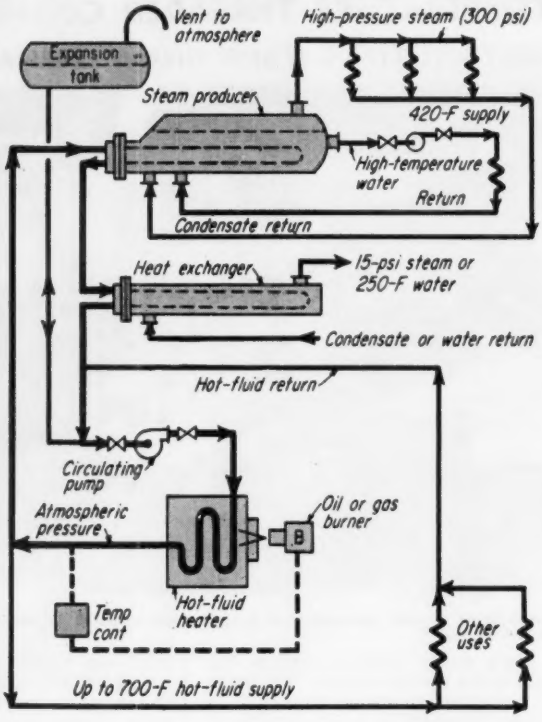
EXCLUSIVE

Equipment design of the month

On this page each month you will see the wraps taken off a significant new product at least 30 days before it's released to any other publication, and before it's advertised anywhere

By STEVE ELONKA
Associate Editor





This steam generator is an "unfired" pressure vessel

Because this packaged steam generator uses a thermal liquid that's vented to atmosphere, it's considered an unfired pressure vessel. Thermal liquids—synthetic fluids some of which have boiling points up to 800 F—are nonflammable, stable and claimed to be noncorrosive.

Developed by the Thermal Systems Division of the American Hydrotherm Corp, these units can be used for process and space heating. The thermal liquid is heated by oil or gas and circulated through a heat exchanger to generate steam at pressures up to 600 psi. It produces water at a maximum of 450 F for process and plant use. Since the heat exchanger which produces steam can be safely located in the factory itself, it removes high pressure from the boilerhouse.

Operation is claimed to be simpler than the conventional high-pressure steam boilers. High-pressure steam outlet is on top of the steam drum and condensate return and makeup enter at the bottom of boiler's steam drum.

There is a pressure gage and liquid-level gage on the steam drum. An indicating temperature control modulates the firing of the burner, which takes its reading from the hot fluids of the circulating pump. Operation is in range of 100 to 700 F.

One temperature controller acts as a high limit control to protect the fluid from overheating. This cuts out the burner if the fluid's temperature rises above a safe limit.

A pressure device protects the fluid if the pump fails. It senses pumping pressure in the fluid circuit and also cuts out the burner if pressure drops. A low-level cutoff is in the expansion tank of the liquid heater. This also cuts out burner if liquid level drops. One pressure-control instrument, on the steam drum, controls the flow of hot liquid to maintain steam pressure at desired setting and also prevents the safety valve from blowing steam.

For additional information, circle No. 77 on Reader Service card, p 125

No. 1 choice for power stations... Crane Pressure-Seal bonnet gate valves

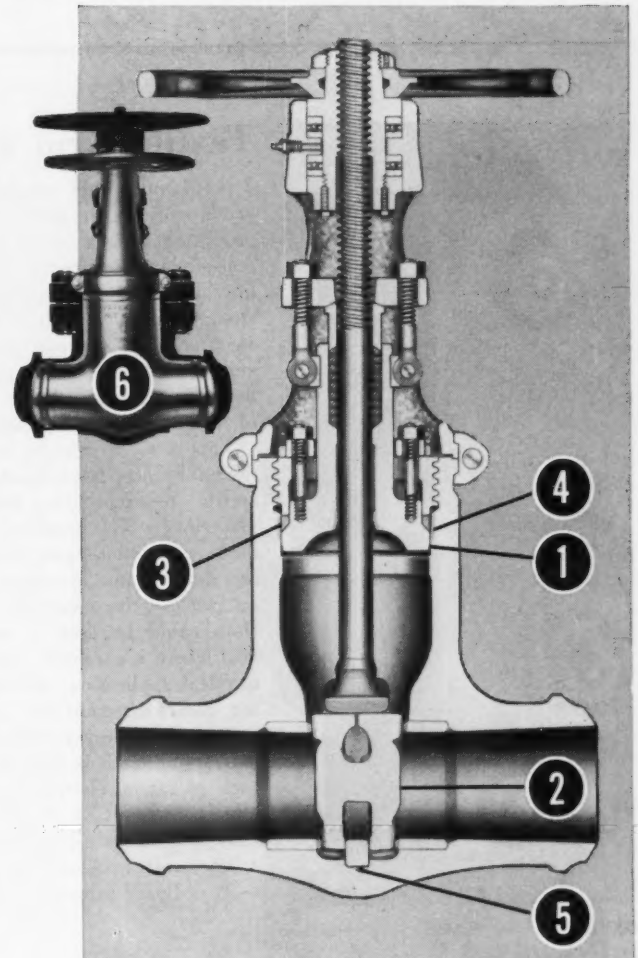
What makes a high-pressure/temperature valve long-lived, safe, dependable and economical to install and maintain?

In Crane Pressure-Seal bonnet gate valves it is:

1. **using internal pressure to seal the bonnet joint —the higher the pressure, the tighter the seal —eliminates bonnet-joint maintenance**
2. **a flexible wedge disc that prevents sticking when valve is closed hot and opened cold . . . doesn't jam even when seated with excessive torque**
3. **a one-piece, silver-plated seal ring held snugly in place by a chrome-plated retaining ring which is screwed into the body; ring remains freeze-free for easy dismantling**
4. **a wear-resisting stainless steel inlay in the body adjacent to the seal ring that insures tight sealing and maximum protection against corrosion at this important point**
5. **full-travel disc guiding—even at critical point of final closure; prevents wear and drag on seating surface**
6. **streamlined, weight-saving design—saves up to 60% of weight of conventional bolted bonnet valves . . . reduces suspension cost . . . simplifies insulating**

Crane 1500-pound Pressure-Seal bonnet globe and angle valves: 1" to 16"; socket- and butt-welding ends.

Crane's complete, expanded line of Pressure-Seal bonnet valves includes gates, globes, angles, globe lift-checks and stop-checks—in all standard sizes, ends and pressure classes. For complete information, see your Crane Representative.



Sizes 1" to 24"; 600-, 900-, 1500- and 2500-pound classes; flanged, socket- and butt-welding ends.

ALL CRANE PRESSURE-SEAL BONNET VALVES ARE ASA RATED

Minimum metal thicknesses comply fully with the requirements of ASA B16.5-1957, as well as ASA Code for Pressure Piping and ASME Boiler and Pressure Vessel Code.

CRANE® VALVES & FITTINGS

PIPE • PLUMBING • HEATING • AIR CONDITIONING

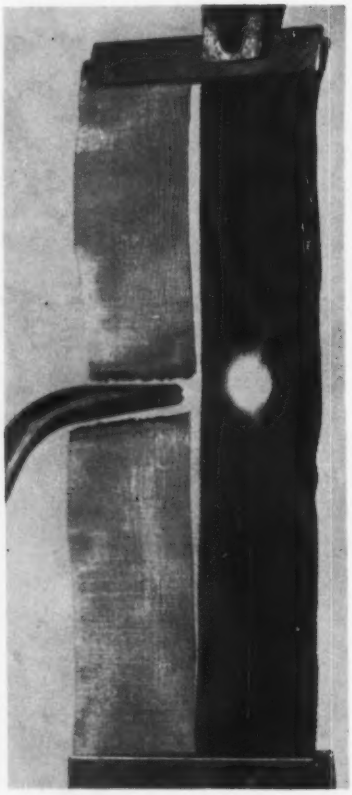
Since 1855—Crane Co., General Offices: Chicago 5, Ill.—Branches and Wholesalers Serving All Areas

In Canada: Crane, Limited, 1170 Beaver Hall Square, Montreal, Que.

For more facts circle 278 on Reader Service card, p 125

For more data on these developments, circle key numbers on Reader Service card, p 125

Plant equipment news... Your



OXYACETYLENE FLAME melts stainless steel, left; graphite cloth, right, won't melt

Textile form opens new fields to graphite

1 • Manufactured graphite is now produced in fiber and fabric form, promising greater scope for the already-versatile mineral. To properties of high- and low-temperature strength, acid and alkali resistance, electrical and thermal conductivity and self-lubrication, graphite's new flexibility adds the major advantage of immunity to thermal shock.

This new form might be used for refractory materials subject to thermal cycling, bag type filters for hot non-oxidizing gases, handling corrosive fluids, electrostatic precipitators, curtain walls, flame arresters. As a resistance-heating element graphite cloth could be used to concentrate heat where it's wanted. Possible mechanical applications are valve packing, gasket materials for high-temperature seals, conveyor belting.

Graphite cloth is made of a fabric such as rayon, electrically heated to almost 5400 F. A thermo-chemical conversion takes place in which crystalline structure of material is changed.

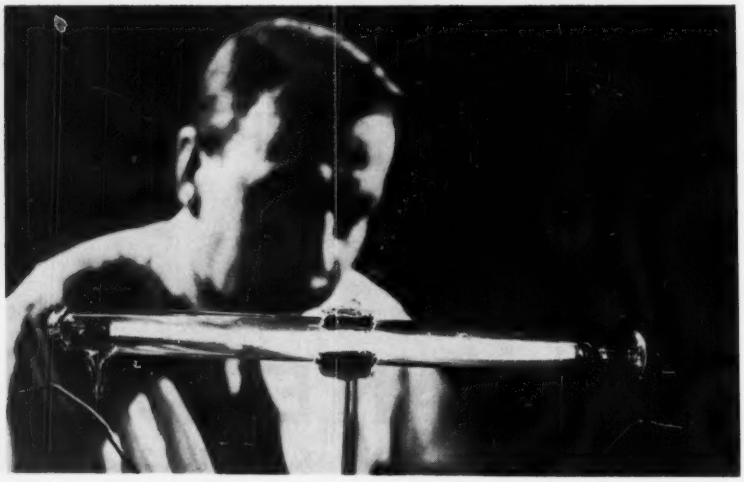
At ordinary pressures graphite has no melting point. It sublimes—goes directly from solid to vapor—at about 6600 F. Graphite gets stronger as heat increases—tensile strength at 4500 F is double its room-temperature strength. At low end of scale, fabrics are unaffected by liquid nitrogen at –320 F.

Graphite textiles resist attack by acids, alkalies and organic compounds except for highly oxidizing ones. They are unreactive with many molten metals. In the nuclear field, graphite moderates high-voltage neutrons to thermal speed with low neutron-capture cross section.

Individual yarns of graphite fabrics have shown tensile strengths up to 15,000 psi. Most textiles have less than 0.1% ash content. Typical room-temperature electrical resistance is 700 micro-ohm cm; this drops off 1/5 at 500 to 600 F, then increases as temperature rises.

Experimental quantities of graphite cloth are being produced at an initial price of about $1.50 per sq ft.—National Carbon Company

RESISTANCE of 700 micro-ohm cm boils water in a resistance-heating demonstration



GRAPHITE-CLOTH STRIP shows its electrical conductivity, thermal stability in evacuated glow tube. Ten-inch strip operated on 110 v gets white hot, radiates 1300 w

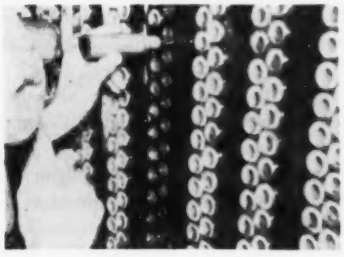
information center for new products and materials

Noncritical fittings have lighter walls

2 • Lighter-than-standard units save money in noncritical service. The stainless-steel fittings and flanges are designed for nominal-temperature low-pressure noncritical process piping; will be stocked in ½- to 4-in. sizes in stainless-steel grades best suited to corrosive applications at 150 psi and less.

Long tangents permit easy alignment of fittings and pipe, allow clearance for fabrication of completely flanged elbows, returns, tees and crosses. One star of the new line is a swivel type insert flange, right. It's made of carbon steel with a stainless-steel insert at the bore into which pipe or fitting can be expanded. You rotate the carbon-steel part to line up the bolt holes and tighten it —no welding needed, maker states.

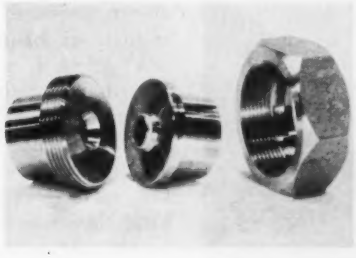
Fittings can be butt welded in the regular way, or fillet welded or brazed. Line includes 45- and 90-deg elbows, returns, reducers, tees and crosses, flared nipples and flanges.—Chemetron Corporation, Tube Turns Div



Plastic condenser-tube inserts install in new and worn tubes

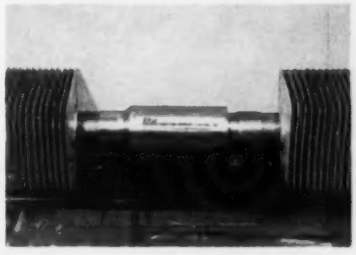
3 • Polyethylene plastic inserts protect inlet ends of power-plant steam-condenser tubes. Standard unit fits new tubes, covers critical area exposed to erosion and is streamlined so it won't restrict water flow.

Expanded unit can be installed in slightly worn tubes. It's made in graduated sizes to match wear pattern in normal installations. Units are pushed into tube by hand, then tapped home with a mallet to produce a tight fit.—Tennant Development Corporation



Corrosion-resistant unions are rated 2000 to 6000 psi

4 • High-pressure pipe unions are designed for use where extreme pressures or corrosive conditions prevail. They're made with threaded or socket-weld ends, of Carpenter 304 or 316 stainless steel that's easily welded, resists corrosion. A wholly confined Teflon seal is used; has tested underwater at over 6000 psi of helium without bubble leaks. Test indicates units would be satisfactory for high-vacuum connections, maker states.—The Special Screw Products Company



Expansion joints handle heating, refrigeration

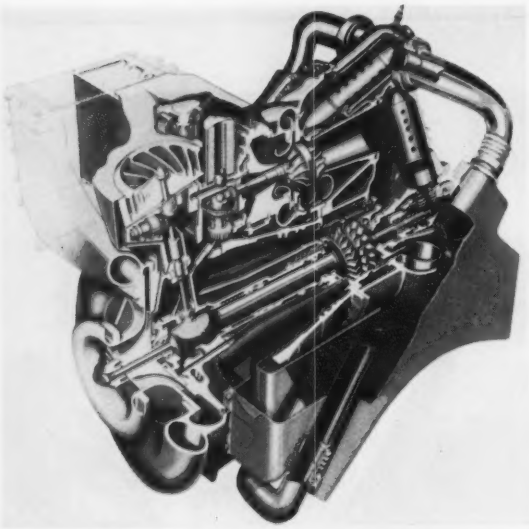
5 • Copper sweat fitting expansion joints are recommended for hot-water heating and refrigeration applications from –30 to +240 F. They have a full two inches of axial expansion, full 360-degree rotation. Seal permits flexibility for alignment. All parts of unit are said to be noncorroding.

Units will dampen pipe noises, control thermal expansion and contraction, according to the manufacturer. There are no metal working parts.—Rotherm Engineering Company, Inc

For more data on these developments, circle key numbers on Reader Service card, p 125

More **equipment news**

For more data on these developments, circle key numbers on Reader Service card, p 125

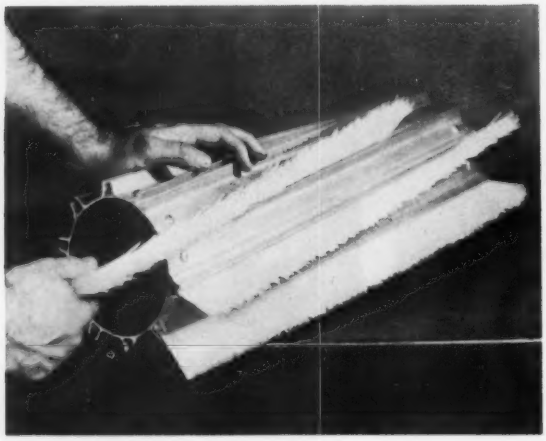


Supercharged gas-turbine engine revs up

6 • Weight only ¼ that of a comparable diesel engine, fuel economy rivaling diesels and superior to conventional gasoline engines under most conditions are features of a 300-hp supercharged gas-turbine engine, the *704*.

Engine uses two stages of air compression, dual burners. Maximum fuel economy is attained in a range of 25 to 100% full power—earlier designs were efficient only at full power. Unit weighs 650 lb installed, complete except for electrical power and fuel. It is 38-in. long, 29-in. wide and 28-in. high. Possible fuels include unleaded gasoline, kerosene and light diesel fuel, and no warmup period is required, maker states. The engine is said to be designed for high reliability and long life.

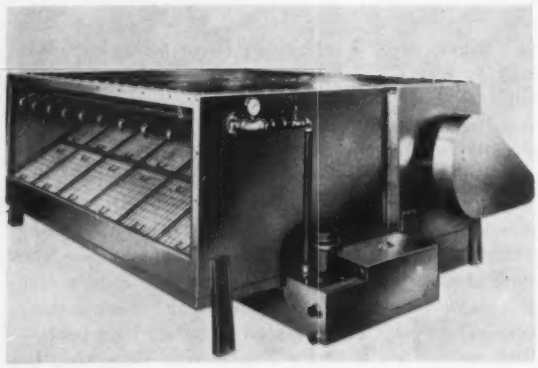
Low-speed compressor turns at 46,500 rpm, high-speed at 91,500 rpm. Primary and reheat combustion chambers operate at 1700 F; exhaust gases discharge at 740 F. Auxiliary, standby power generation will be some uses for the unit, now in final test stage.—Ford Motor Co



Carryback brush sweeps belts cleaner

7 • Said to be low-cost and efficient, new conveyor-belt brush is made up of an extruded-aluminum mounting and synthetic strip brushes of *Korfil P*. Bristle material won't absorb moisture, so it doesn't soften or become brittle in high- or low-temperature service. Acids and alkalies don't affect it, according to the manufacturer, and it's rugged, performing well with coal and other abrasive materials. Brush comes in three fill sizes, .040, .028 and .016 in., suitable for various duties.

Unit sweeps belt clean of carryback without injuring belt surface—individual strip-brush inserts develop a brushing action 80 to 100% effective. Strip brushes can be replaced on the job. Hard-rubber end bushings support the mounting on the shaft—rubber won't mark shaft and doesn't corrode.—The Osborn Manufacturing Co



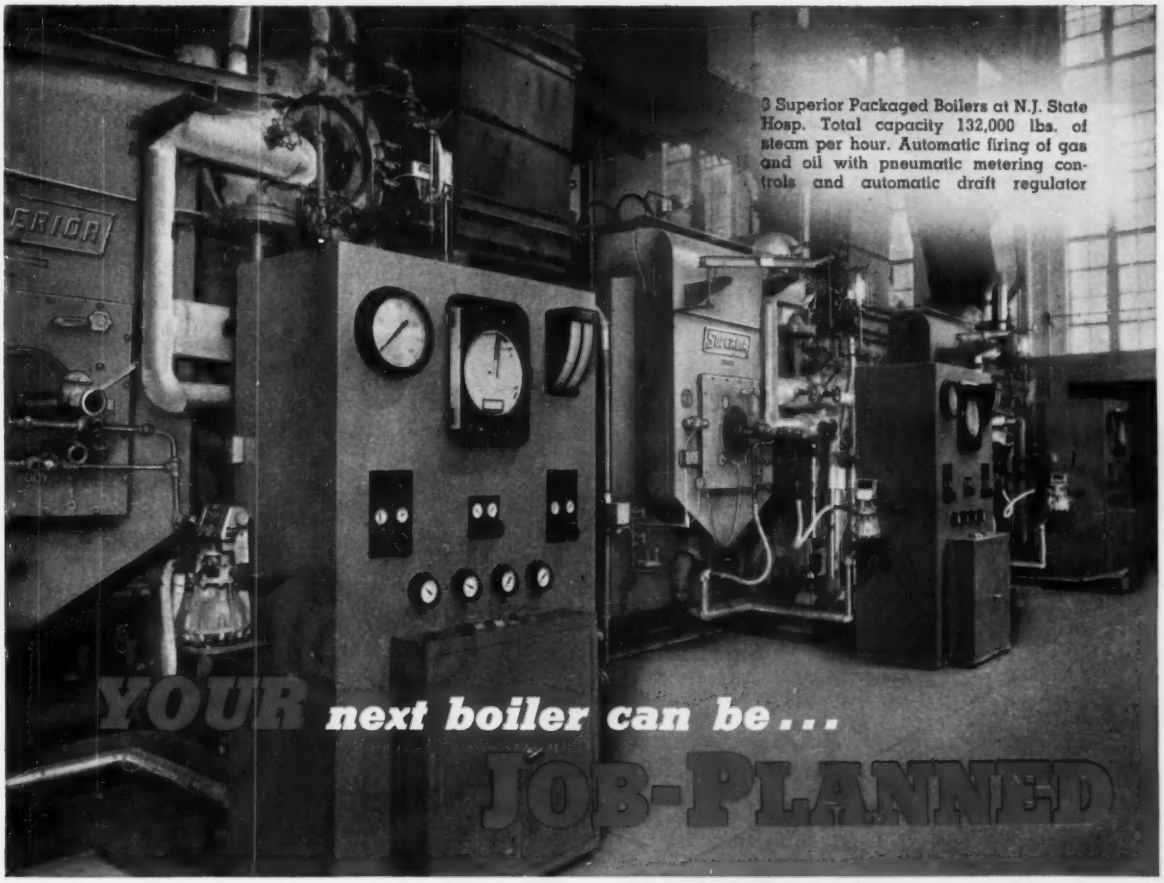
H-p, capillary air conditioners available

8 • Expanded line of central-station air conditioners now covers high-pressure and capillary models. Units are factory assembled, recommended for static pressures from ¼ to 9-in. wg. deliveries from 800 to 40,000 cfm.

Capillary conditioner, left, has sprays acting on glass-filled capillary cells to produce highly saturated air through evaporative cooling. Cells also do duty as air filters, removing normal dust, mold and spores.

New high-pressure units have oversized shaft, heavy-duty fan and well-supported bearings. H-p section is isolated from coils, accessories and ductwork by flexible connections.—American-Standard Industrial Div

For more data on these developments, circle key numbers on Reader Service card, p 125


3 Superior Packaged Boilers at N.J. State Hosp. Total capacity 132,000 lbs. of steam per hour. Automatic firing of gas and oil with pneumatic metering controls and automatic draft regulator
YOUR next boiler can be...
JOB-PLANNED

and FACTORY-FIRE-TESTED ... Too!

Flexibility of choice with a complete "Superior Guaranteed Package"

Capacities to 61,000 lbs. per hour.
Design pressure to 900 p.s.i.g.
Fully or semi-automatic operation.
Integrated console or free-standing panel.
Electric or pneumatic metering combustion controls.
Electric position (parallel) combustion controls.
Rotary cup burner to 27,000 lbs. per hour.
Single or multiple steam atomizing burners.
Single or twin element feedwater regulator
Steam or air puff soot blowers.
Low and high duty superheaters.
Separate packaged economizers.

All this with undivided responsibility, guaranteed performance and efficiency for minimum maintenance.

Why not choose your "guaranteed" packaged boiler to meet the needs of your job, just as you would when specifying a field-erected plant, and still get the advantages of factory assembly, factory-fire-testing, and most important, undivided responsibility?

The Superior Packaged Boilers pictured here are "job-planned" units incorporating burner and control equipment as specified by the purchaser, and tested at actual working conditions before shipment.

Testing involves all functional equipment: forced draft fan, burner, combustion controls, programming equipment, etc., mounted or connected to the boiler, thus providing a guaranteed product with undivided responsibility. Why settle for less? Why purchase half a package? For details write for Catalog 1000-W.

Specialists in PACKAGED BOILERS... exclusively

SUPERIOR COMBUSTION INDUSTRIES INC.
TIMES TOWER, TIMES SQUARE, NEW YORK 36, N.Y.

SUPERIOR
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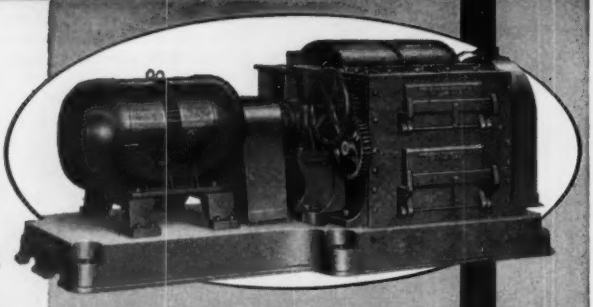
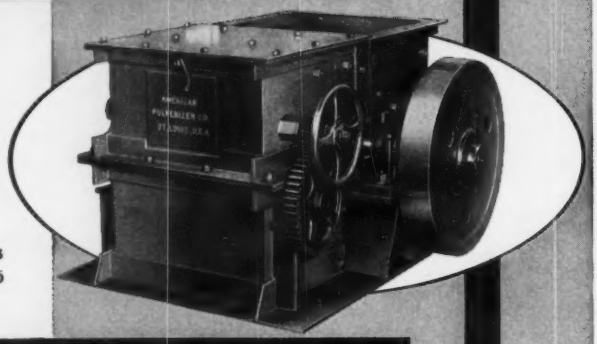
When You Figure . . .



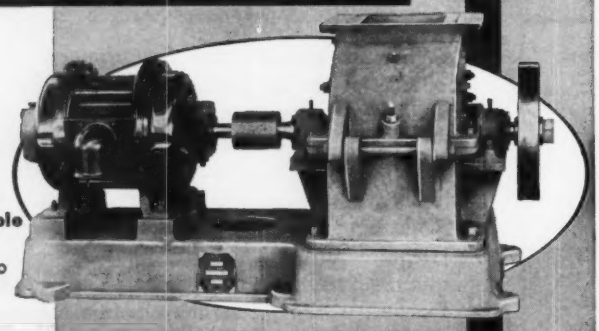
AC Series
capacities to
800 TPH

Reduction
Cost Per Ton . . .



WC Series
capacities to
90 TPH

the Best Answers*. . .



Coal Sample
Crushers
capacities to
2000 Lbs.
Per Hr.

Come from American
Ring Coal Crushers

*In a recent independent survey, it was found that American Crushers reduced over 61,000,000 tons of coal at a parts replacement cost (including standby parts) of less than 1/10th of 1¢ per ton.

THERE CAN BE NO BETTER PROOF OF AMERICAN QUALITY!

American
PULVERIZER COMPANY

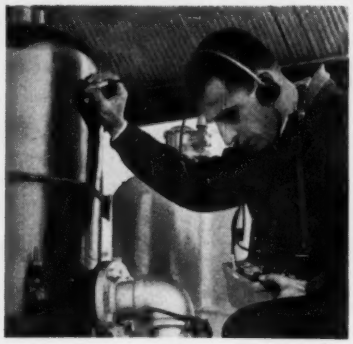
WRITE for Literature on These Crushers

Originators and Manufacturers of Ring Crushers and Pulverizers

1349 MACKLIND AVE. • ST. LOUIS 10, MO.

Equipment news

Begins on page 140

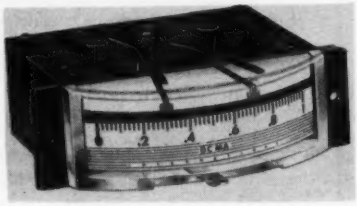


Ultrasonic thickness tester

37 • Completely self-contained unit weighs less than five pounds, including batteries, probe, harness, cable and earphones. It can be used for nondestructive thickness measurement of most metals, glass, ceramics and plastics from one side. Because no outside source of power is needed, unit is ideal for corrosion inspection in the field.

A high-sensitivity ceramic transducer is applied to one surface of material under test, and instrument indicates harmonic resonances by a signal in the headphones and by deflection of a small indicator. Computation and conversion of frequency to thickness is registered on a panel meter. Unit is direct reading for steel, aluminum or copper; a fourth position permits calibration for other materials. Accuracy is within 3 to 5%.—Branson Instruments, Inc

Just circle key numbers on the Reader Service card, page 125, to get complete product story



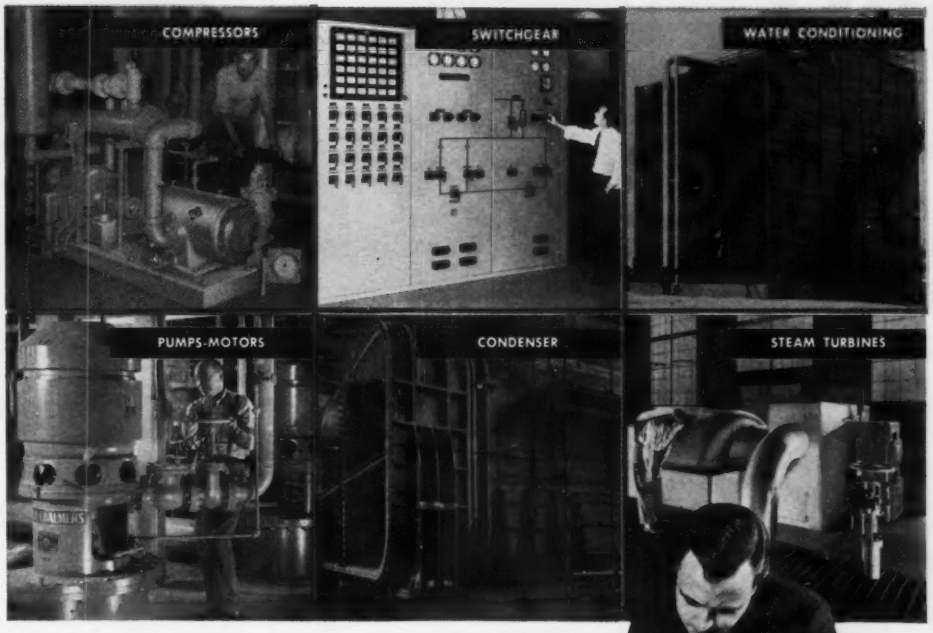
Miniaturized control meter

22 • Electronic control meter operates without use of contacts at the set points. Movement of pointer is not stopped at set points, and full scale range is available for readings at all times.

Extra current is not needed for proper contacting. Contact resistance,

In pace with POWER... ALLIS-CHALMERS

ALLIS-CHALMERS



ONE MAN...

Your Allis-Chalmers man... can supply and coordinate all this equipment and more

Compressors, switchgear, condensers, steam turbines, motors, pumps and water conditioning equipment — Allis-Chalmers builds them all.

But equipment is not the whole story. You get more, much more than fine equipment when you specify Allis-Chalmers.

- There's the obvious time- and money-saving advantage of single-source buying.
- The coordination of drive to driven part.
- The coordination of engineering and delivery.
- The unit responsibility for equipment in service.

Whatever your power equipment problem may be... there's one man to call — your nearby A-C engineer. His recommendations are backed by experts on the particular equipment involved. *Allis-Chalmers, Milwaukee 1, Wisconsin.*

Plan to stay ahead... MODERNIZE!

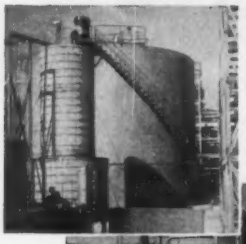
A-C ALLIS-CHALMERS

A-5991-PR

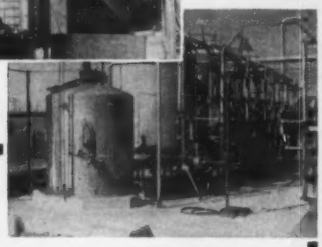
ALLIS-CHALMERS

WHO CHOSE H&T ?

For Boiler Feedwater Conditioning Equipment



400,000 lb. per hour fully automatic demineralizer plant with silica and CO_2 removal



These Fine Companies Did!

A Partial List of Installations

Duquesne Light Co.
Shippingport, Pa.

Yankee Atomic Electric Plant
Rowe, Mass.

Ohio-Edison Co.
Akron, Ohio

Bowaters-Carolina Corp.
Catawba, S.C.

Knolls Atomic Power Laboratory
West Milton, N. Y.

The Cleveland Elec. Illuminating Co.
Ashtabula, Ohio

Chevrolet Div. Gen. Motors Corp.
Tarrytown, N. Y.

R. J. Reynolds Tobacco Co.
Stokes County, N. C.

Tampa Electric Co.
Tampa, Florida

U. S. Gypsum Co.
Chicago, Ill.

Send for new Bulletin
50 Years of Progress

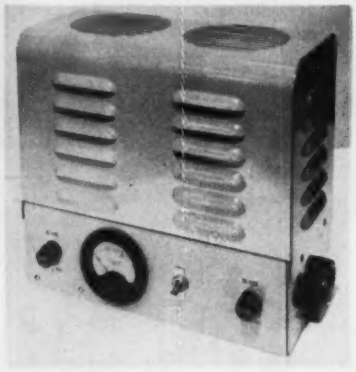
HUNGERFORD & TERRY, Inc.
CLAYTON 3 — NEW JERSEY
H&T SERVICE

Equipment news

Begins on page 140

flutter, corrosion and "spot welding" are eliminated, maker states.

Horizontal-mounted units come with a scale length of 2.7 in., panel area of 5.5 sq in.—International Instruments Inc



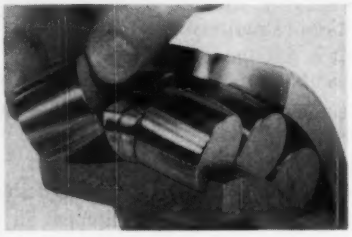
Unitized power package

34 • Peak dc power to trip circuit breakers is always at hand with this battery-charger combination. High-capacity lead-calcium grid control batteries and compact silicon charger provide a dependable power package needing little maintenance. Battery is fully charged automatically, always ready for action.

During time breaker is tripped battery also supplies necessary constant load current for operation of pilot lights or holding coils.

Charger operates from a 115-volt 60-cycle single-phase source. It can be mounted on the door of the circuit-breaker cubicle, on the wall, on a rack panel or outdoors.—C & D Batteries, Inc

Just circle key numbers on the Reader Service card, page 125, to get complete product story



Spherical roller bearings

36 • Highest-capacity units feature large convex rollers, precision-machined centrifugally cast bronze re-

This Yarway team has scored high—over a million installed on all types of steam equipment. Stocked and sold by 270 Industrial Distributors. For free Steam Trap Book, write YARNALL-WARING CO., 100 Mermaid Ave., Philadelphia 18, Pa.

go YARWAY with confidence

circle 282 on Reader Service card, p 125

circle 283 on Reader Service card, p 125

In pace with POWER... **ALLIS-CHALMERS**

ALLIS-CHALMERS

Exclusive electrical and manual stored-energy closing mechanism.

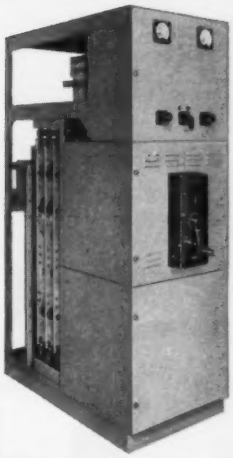
Convenience — control devices located on breaker front—safely available even with door closed.

Plus Value in every detail

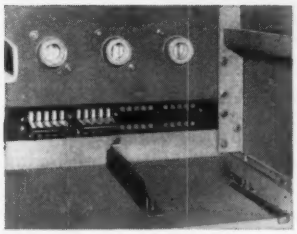
Allis-Chalmers all-new 600-volt metal-enclosed switchgear for 75,000-ampere interrupting service

Just a few of the operating... safety... and application features of A-C's new design are shown. There are many other features that will interest you, such as unitized construction, the use of polyester glass insulation, and spring-held dust seals.

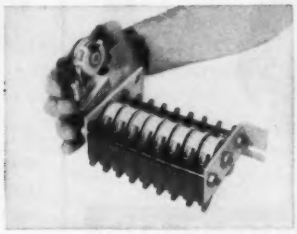
Get the details! Contact your nearby A-C office or Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin.



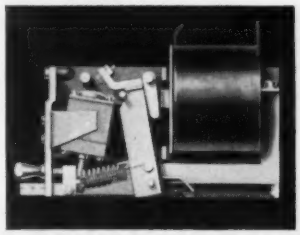
Safety — breaker shown in disconnected position . . . stored with door closed. The indicators show circuit breaker position.



Safety—*(a)* interlock prevents movement of closed breaker; *(b)* latch prevents rocking past disconnect position.



Flexibility—each stage of auxiliary switch assembly is individually adjustable without disassembly.



Accuracy — direct acting series-trip device is set easily, using calibration scale and adjusting knob.

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A-1038-PR

ALLIS-CHALMERS

For more facts circle 284 on Reader Service card, p 125

ROTOJET®

Cleans TUBES and PIPES

ANY SIZE

from ½" to 12" I.D.

STRAIGHT or CURVED

Roto engineers are constantly designing new equipment to meet new conditions and applications for its tube cleaners. If you have a pipe or tube cleaning problem, we will be pleased to place our long specialized experience at your disposal. Write, wire or

Phone HUmboldt 3-0570

Illustrated are a few of the many types and sizes of Rotojet Tube Cleaners driven by air, steam or water. We analyze each application before recommending equipment that best meets the requirement.

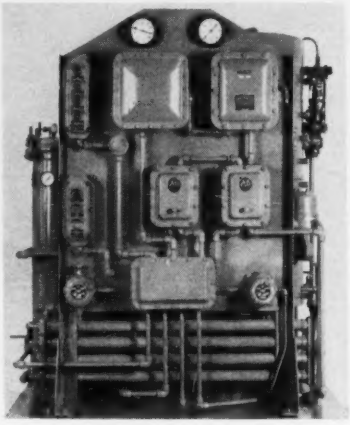
ELLIOTT COMPANY – ROTO PLANT

Tube Cleaner Specialists Since 1910

153 Sussex Avenue, Newark, N. J.

tainers and high, heavy inner race shoulders. All components are in optimum balance for long maintenance-free performance, maker states.

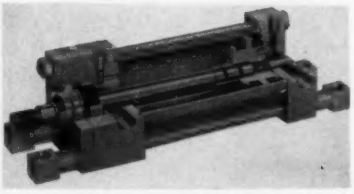
Units come in bore sizes from 1.5748 to 11.0236-in. with dynamic load ratings up to 288,000 lb. Later models will be made in pillow blocks, in bore sizes from 1 7/16 to 10 in.—Link-Belt Company



Oil reclaimer

32 • Designed for purification of diesel-engine lube oil at a flow rate of 100 gph, unit uses all explosion-proof electric equipment. Construction is all-steel. An inlet fuller's-earth filter, an automatic draining distillate collection tank, and steam-heater vacuum vaporization chamber are features.—The Hilliard Corporation

Just circle key numbers on the Reader Service card, page 125, to get complete product story



Air cylinders

27 • Square-end double-acting units are designed for holding, positioning, moving work or making fatiguing motions automatic. Available in five sizes up to 4-in. bore, cylinders take air pressure to 250 psi or hydraulic pressure to 750 psi. Each size is available with or without adjustable cush-

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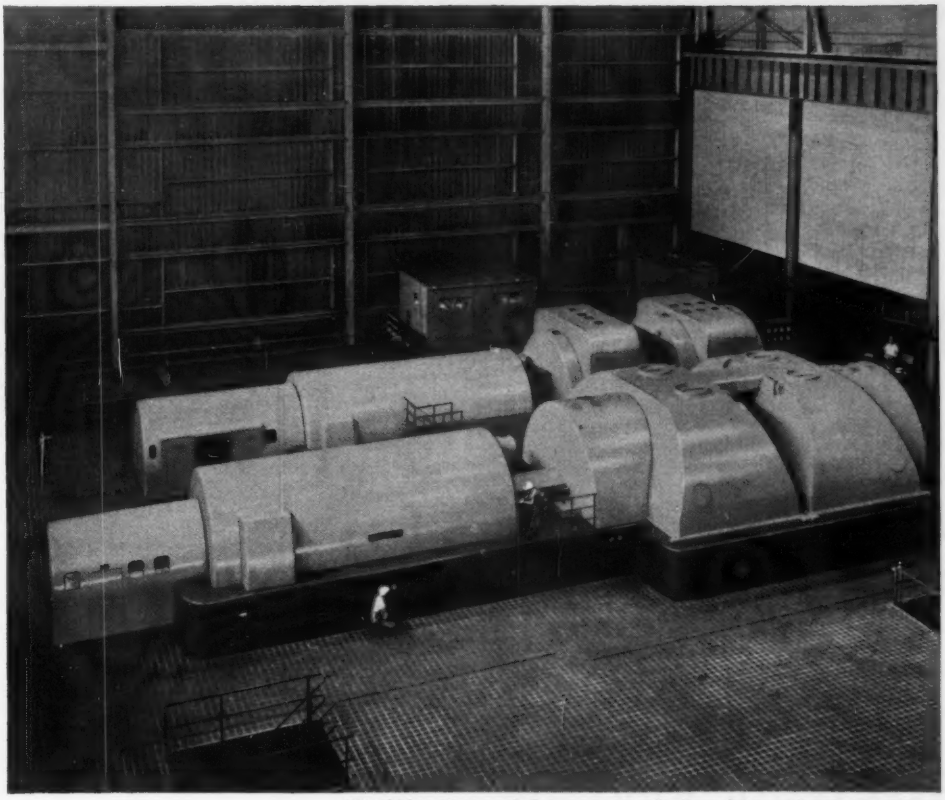

321,500-kw, close-coupled, cross-compound reheat design with two generators... one on 3600-rpm shaft... and one on 1800-rpm shaft. Steam conditions: 2400 psig, 1050 F at inlet; 1000 F reheat; 1 inch Hg absolute exhaust pressure.

ALLIS-CHALMERS

Detroit Edison's new 321,500-kw machine goes on the line

River Rouge Unit 3 increases the capacity of the Detroit Edison system to 3¼ million kilowatts — double its capacity of 10 years ago.

In size, in design, this steam turbine-generator unit was the beginning of a new era in power generation.

Of special interest are the record size 46-inch exhaust blades; and the close-coupled arrangement with the crossunder piping located above the foundation which made it possible to build to compact over-all dimensions.

For an interesting discussion of this turbine, see ASME paper 58-SA-22 . . . available through your nearby A-C office or Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin.

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A-C ALLIS-CHALMERS

A-5938-PR

FORGED for long life
PACKAGED for convenience

The "Forged" in W-S Forged Fittings means dependability under the toughest piping-job conditions. "Forged" gives you the added resistance to pressure, heat, corrosion, shock and vibration needed to make your installations long-lived and safe. And W-S Fittings are easily installed, with tight fits and perfect alignment . . . thanks to W-S precision machining methods and quality forging techniques.

Packaging, too, is a W-S brand advantage. Virtually any "mix" of fitting types and sizes can be packed in a convenient W-S Case or Half-case . . . each type and size in its own carton.

Specify W-S on your next order. For specifications and Distributor locations, write *Forge and Fittings Division, H. K. Porter Company, Inc., Box 95, Roselle, New Jersey.*

FORGE AND PORTER FITTINGS DIVISION

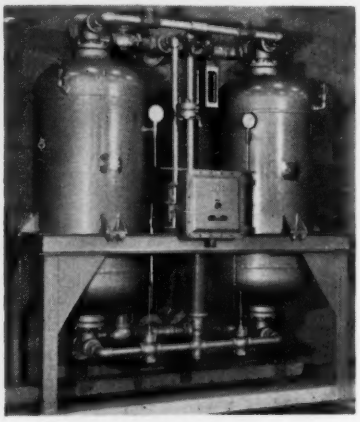
H.K. PORTER COMPANY, INC.

PORTER SERVES INDUSTRY: with Rubber and Friction Products—THERMOID DIVISION; Electrical Equipment—DELTA-STAR ELECTRIC DIVISION, NATIONAL ELECTRIC DIVISION; Copper and Alloys—RIVERSIDE-ALLOY METAL DIVISION; Refractories—REFRACTORIES DIVISION; Electric Furnace Steel—CONNORS STEEL DIVISION, VULCAN-KIDD STEEL DIVISION; Fabricated Products—DISSTON DIVISION, FORGE AND FITTINGS DIVISION, LESCHEN WIRE ROPE DIVISION, MOULDINGS DIVISION; and in Canada, Refractories, "Disstor" Tools, "Federal" Wires and Cables, "Nepcoduct" Systems—H. K. PORTER COMPANY (CANADA) LTD.

Equipment news

Begins on page 140

ion. Bolt, flush, leg, base or side-flush mounting is available.—Scovill Manufacturing Company, A Schrader's Son Div

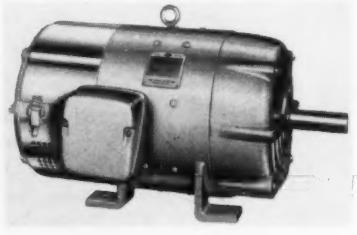


Desiccant driers

14 • Air can be delivered at a dewpoint below – 200 F, according to maker. Units are available in a wide size range, from wall-mounted for small flows to floor models handling compressed gases at thousands of cfm. They operate at pressures from 30 to 6000 psig.

Drier can remove oil vapors from compressed gases to a purity of one ppm. There is no temperature increase in the effluent gas.—Trinity Equipment Corporation

Just circle key numbers on the Reader Service card, page 125, to get complete product story



Dc motors

23 • *Flexitorq* motors are said to combine fast response, a wide speed range and high overload capacity in a light, compact machine. Units are available in ratings of 1 to 200 hp, in dripproof and dripproof-guarded enclosures.

Improved performance characteristics include fast acceleration, de-

ALLIS-CHALMERS

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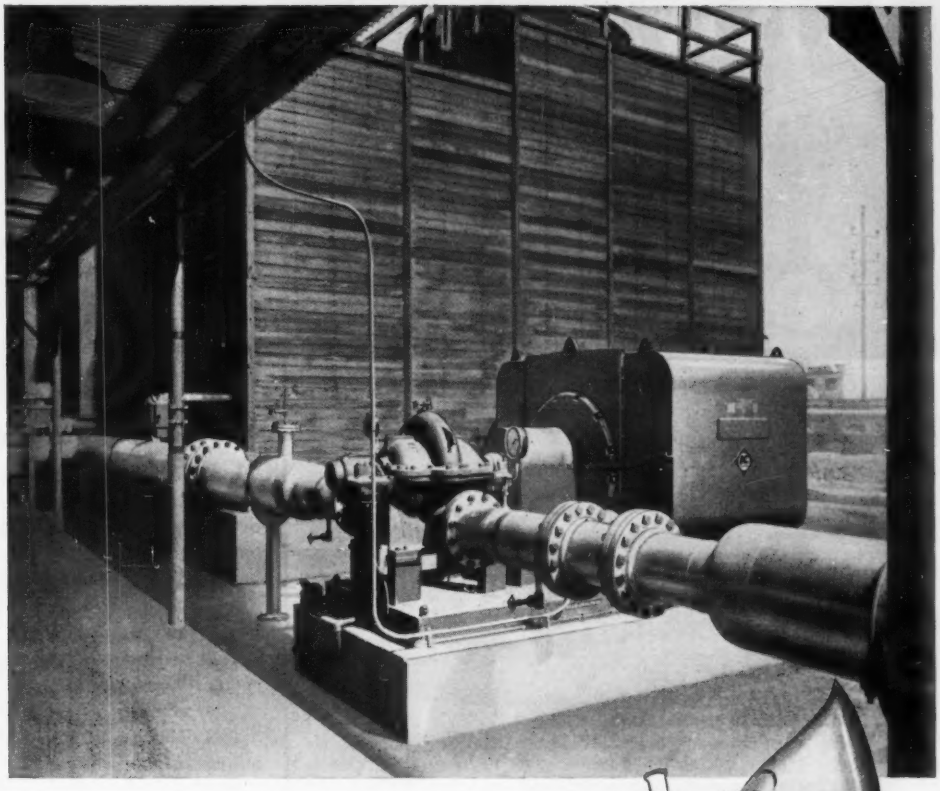


CONTROL ALGAE

easy, low-cost way

Eliminate problems of plugged pump strainers, coated heat-exchanger tubes and coated slots in cooling towers.

Control is safe . . . quick with Allis-Chalmers No. 120 Series Algaecide.

This algaecide is toxic to more algae than any other. On the other hand, it has low toxicity to fish or animals and is extremely safe to handle. Even in concentrated form it is only a mild irritant to skin and hands.

A little goes a long way! Only 2 to 5 ppm are required for effective dosage of most organisms. It's easy to feed into the system . . . and is non-oxidizing and corrosion inhibiting.

No water conditioning specialist needed to use it! Buy it and try it. Purchase directly from your nearby A-C office or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin.

A-C ALLIS-CHALMERS

A-5972-PR

ALLIS-CHALMERS

DO YOU KNOW WHY

FAIRBANKS VALVES

ARE BEING SPECIFIED AND INSTALLED IN THE NATION'S NEWEST MOST MODERN BUILDINGS?

ESSO RESEARCH BUILDING #16 Linden, N. J.
OWNER: Esso Research and Engineering Co., Linden, N. J. ARCHITECT AND ENGINEER: Voorhees, Walker, Smith and Smith, New York, N. Y. GENERAL CONTRACTOR: Frank Briscoe Co., Paterson N. J. MECHANICAL PIPING CONTRACTOR: Frank A. McBride Co., Paterson, N. J.

● Because Fairbanks Valves are Quality—DEPENDABLE—products.

● Because, over the past 67 years, long-lasting, trouble-free service has proven the DEPENDABILITY of Fairbanks Valves to the nation's leading consulting engineers, architects and contractors who have specified and installed these valves in the systems for which they were responsible. This acceptance of Fairbanks Valves is demonstrated by the fact that in over 50% of the new building construction described in an ENGINEERING NEWS-RECORD article "Office Building Boom Alters New York City Skyline", January 17, 1957, Fairbanks Valves were specified and installed.

● Because Fairbanks offers a full line of Bronze and Iron Body Valves for heating, piping and air conditioning systems.

● Because Fairbanks Valves are available the country over through stock carrying distributors in all the principal cities.

Do you have a copy of Fairbanks current Valve Catalog and Valve Comparison Chart? It will be a pleasure to send a copy of each to you.

THE Fairbanks COMPANY

EXECUTIVE OFFICE: 393 LAFAYETTE STREET, NEW YORK 3, NEW YORK

VALVES • DART UNIONS • CASTERS • TRUCKS • WHEELS

Branches:

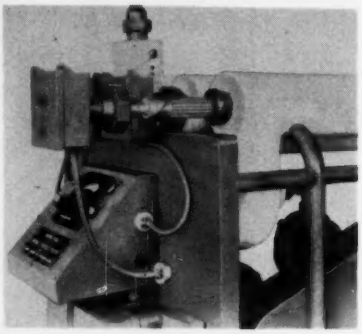
520 Atlantic Avenue Boston 10, Mass. | 2600 So. Throop St. Chicago 8, Ill. | 393 Lafayette Street New York 3, N. Y. | 15 Stanwix Street Pittsburgh 22, Pa. | 202 Division Street Rome, Ga.

Plants: Binghamton, N. Y. • Rome, Ga.

Equipment news

Begins on page 140

celeration, reversing and speed changing, possible because of a low-inertia armature and better commutating ability, according to manufacturer. Class B insulation is used throughout.—The Louis Allis Co



Heat-transfer system

41 • Accurately controlled heat source, constant fluid velocity guard against overheating damage at high temperatures in this liquid-phase heat-transfer system. Heating system has finned-tube design with radial fins parallel to heater axis. This produces maximum heat transfer without return bend obstruction, according to the maker. Fins make possible higher, completely controlled heat output from a shorter tube.

Size of system depends on number of heating elements installed. Each element is rated 8 kw with a design output of 25,000 Btu per hr. System isn't limited to heating individual process—it can be used as a central system to heat various different-temperature processes at the same time. —Trent, Inc

Just circle key numbers on the Reader Service card, page 125, to get complete product story

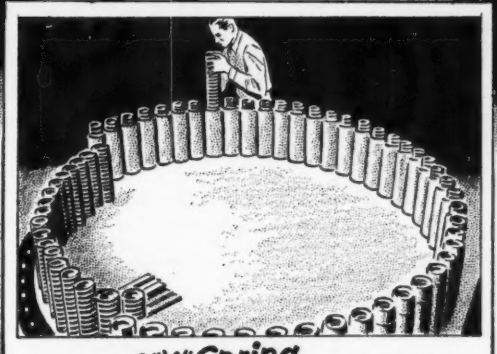
Btu meter

25 • A single unit records, indicates and integrates Btu loss or gain of a flowing liquid in *Model-913* Btu meter. Temperature differential and liquid flow rate are also recorded on the chart. Applications include heat-transfer measurement in hot-water generators, cooling towers, refrigerating systems.

Two differential-connected platinum resistance temperature elements measure inlet and outlet temperature of liquid. They form two legs of a

A "stitch-in-time" (Monel) once saved Miss Liberty

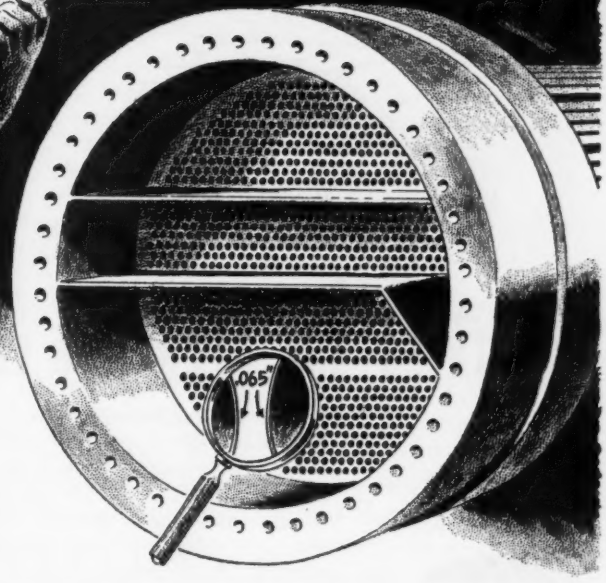
IN 1938 MISS LIBERTY WAS DANGEROUSLY CLOSE TO FALLING APART AT THE SEAMS. CORROSIVE ATTACK BY SALT AIR AND INDUSTRIAL FUMES HAD WEAKENED AND LOOSENED RIVETS HOLDING THE STATUE'S HUGE METAL PLATES TOGETHER. BUT SHE WAS SAVED BY 65,000 MONEL* NICKEL-COPPER ALLOY SELF-TAPPING SCREWS WHICH PULLED THE PLATES UP TIGHT. THESE STRONG, CORROSION-RESISTING "STITCHES" STILL LOOK GOOD TODAY—20 YEARS LATER.



Inconel "X" Spring starves "hungry" water...

Withstands corrosive bite of 13,000 tons per hour, at 600°F

13,000 TONS PER HOUR OF HIGH-PURITY WATER AT 500-600°F FLOWS AROUND THE SPRINGS USED TO SUPPORT THE CORE STRUCTURE OF A NUCLEAR POWER REACTOR. TO PREVENT STRESS-CORROSION CRACKING OR EMBRITTLEMENT, THE DESIGNERS CALLED FOR INCONEL "X"* AGE-HARDENABLE NICKEL-CHROMIUM ALLOY. SPRINGS MADE OF THIS ALLOY RESIST CORROSION AND RELAXATION AT HIGH TEMPERATURES—UP TO 1100° IN SOME CASES!



Thin-wall 4300psi heater tubes—5/8" O.D.

THESE ARE THE FACTS ON THE MONEL ALLOY U-TUBES IN FINAL STAGE FEEDWATER HEATERS, NOW AT A NEW OHIO POWER STATION. THEIR 85-FOOT LENGTH MAKES THEM THE LONGEST MONEL ALLOY TUBES EVER MADE. ALTHOUGH THESE TUBES ARE DESIGNED TO WITHSTAND A WATER PRESSURE OF 4300 PSI, THEY'RE ATTACHED TO THE TUBE SHEETS BY ROLLING ONLY! QUITE A TRIBUTE TO STRENGTH AND DUCTILITY OF MONEL ALLOY.

Need help on a metal problem?

THERE'S A GOOD CHANCE THAT INCO'S MECHANICAL ENGINEERING SECTION HAS ALREADY SOLVED A PROBLEM SIMILAR TO YOURS. WHY NOT CONTACT THEM RIGHT AWAY FOR ASSISTANCE? JUST LET US KNOW THE DETAILS.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

INCO TRADE MARK

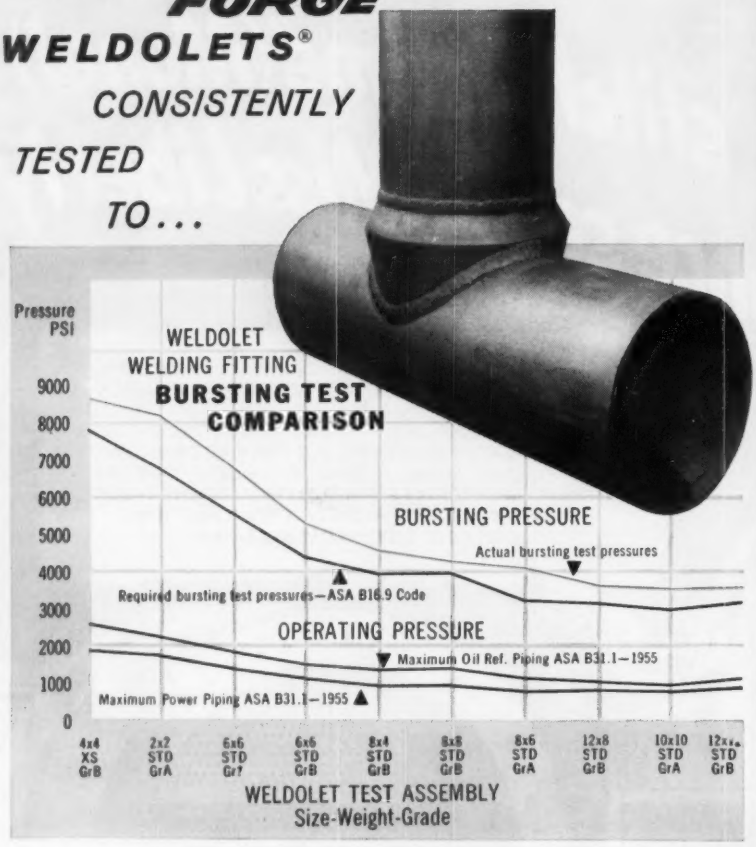
*Registered trademark

INCO NICKEL ALLOYS

For more facts circle 290 on Reader Service card, p 125

BONNEY FORGE

WELDOLETS® CONSISTENTLY TESTED TO...



...OVER
4½ TIMES MAX. OPERATING PRESSURE

"Shape of Reinforcement"—has been pioneered by Bonney for the past 20 years. The fact that shape is as important and even more important than area replacement for branch reinforcement is now gaining wide industry recognition. Even though Weldolets *do* have sufficient area replacement, the factor setting them apart from conventional lap type reinforcement is their SHAPE . . . Reinforcement close to the juncture—completely bonded homogeneous reinforcement avoiding cracks, fillet welds, and re-entrant corners—reinforcement tapering at the sides to prevent abrupt change in thickness where fitting joins header pipe.

Recent design improvements in the Weldolet line, based on extensive stress analysis tests, provide all these desirable "shape" factors. Specify and use Weldolets for all your full size and reducing branch connections. They are available in carbon steel and all alloys for any piping service.

BONNEY

WELDOLETS®
THREDOLETS®
SOCKOLETS®
ELBOLETS®
BRAZOLETS®
SWEEPOLETS®

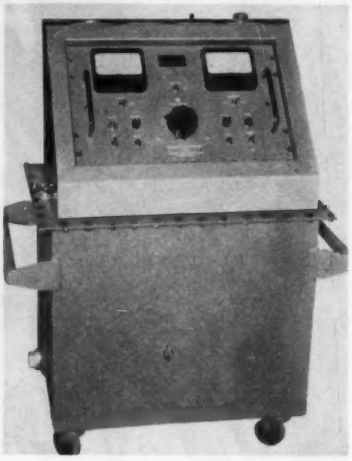
CARBON STEEL
STAINLESS
ALLOY
for all services

BONNEY FORGE and TOOL WORKS
ALLENTOWN, PENNSYLVANIA

Equipment news

Begins on page 140

resistance bridge in which differential temperature receiver acts as a rebalancing unit.—Hays Corporation

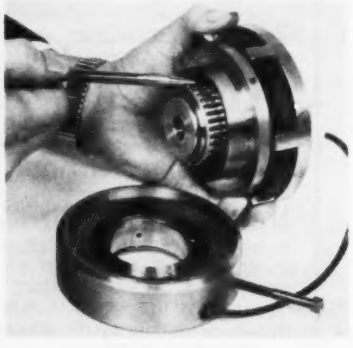


Dc overpotential tester

21 • This tester comes in two pieces; it may be stacked, above, for mobile use and rolled to the job. Output is 120,000 v, and unit has selenium rectifiers for rugged operation, according to the maker.

Control section is easily removed from high-voltage tank section for remote control. Testers are also available in 50-, 100-, 150- and 200-kv ratings.—Peschel Electronics, Inc

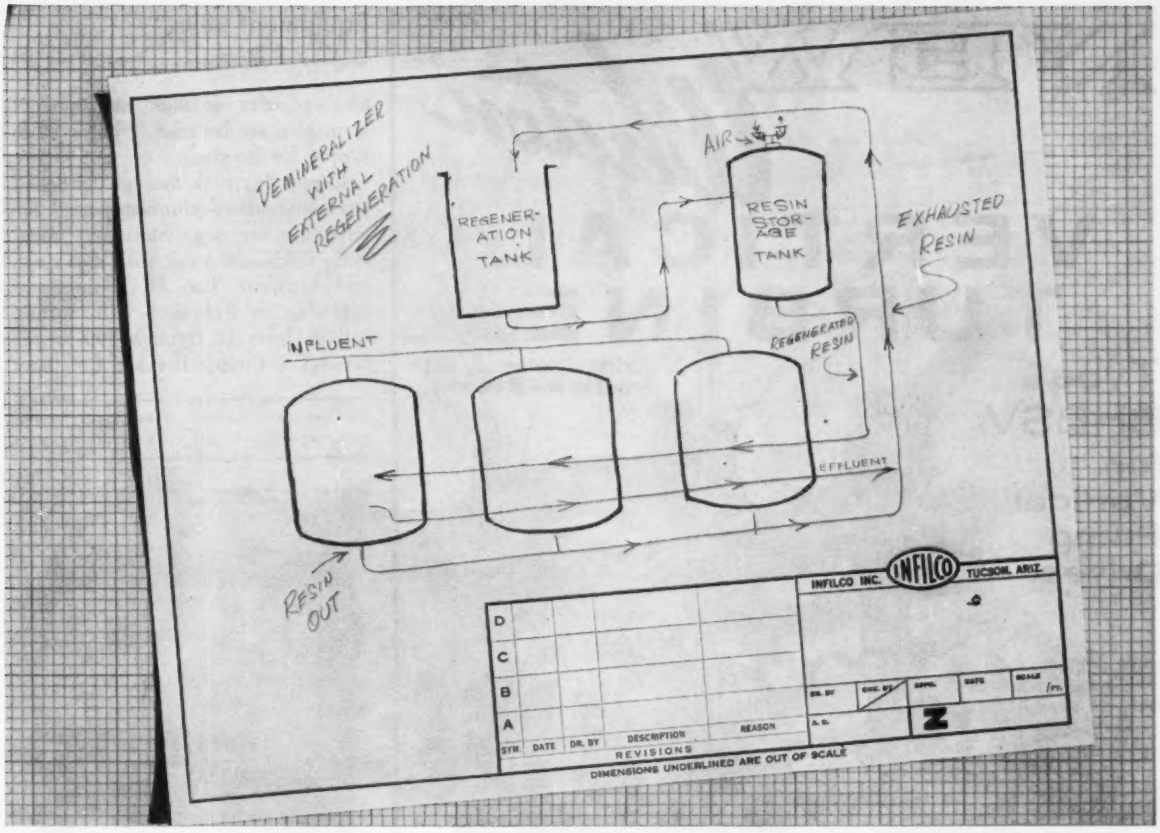
Just circle key numbers on the Reader Service card, page 125, to get complete product story



Magnetic clutch

39 • Heart of new clutch is an angular-split air gap which converts part of thrust load to bear against radial bearing, above. Unit is said to virtually eliminate need for maintenance in machine transmissions; it

For more facts circle 291 on Reader Service card, p 125



ADVANCED demineralization equipment

...for specialized applications

Varied and increasingly stringent demineralized water requirements necessitate custom-made methods and equipment for many applications. Through the years INFILCO has furnished equipment for many of these "problem" jobs. These are typical examples—

INFILCO furnished the *first* high flow rate demineralizers (50 GPM per square foot) to polish condensate for a nuclear power reactor. This equipment has been operating successfully for over a year at the Vallecitos Atomic Power Plant of General Electric Company and Pacific Gas and Electric Co.

A similar INFILCO plant, having a capacity of 3200 GPM at 50 GPM per square foot, with complete external regeneration facilities, will polish condensate for the 180,000 KW dual cycle boiling water reactor at the Dresden Nuclear Power Station of Commonwealth Edison Company. This plant is discussed in Reprint 88.

Now INFILCO can furnish equipment, using these modern operating and regeneration techniques for large raw water demineralizers to produce high quality water, with less investment than would be required with other types of equipment. Reprint 92 tells the complete story.

If you have a demineralization problem, we can help you solve it efficiently and economically. If our standard line of equipment does not meet your particular requirements we can offer a custom designed plant to do the job.

INFILCO

8501

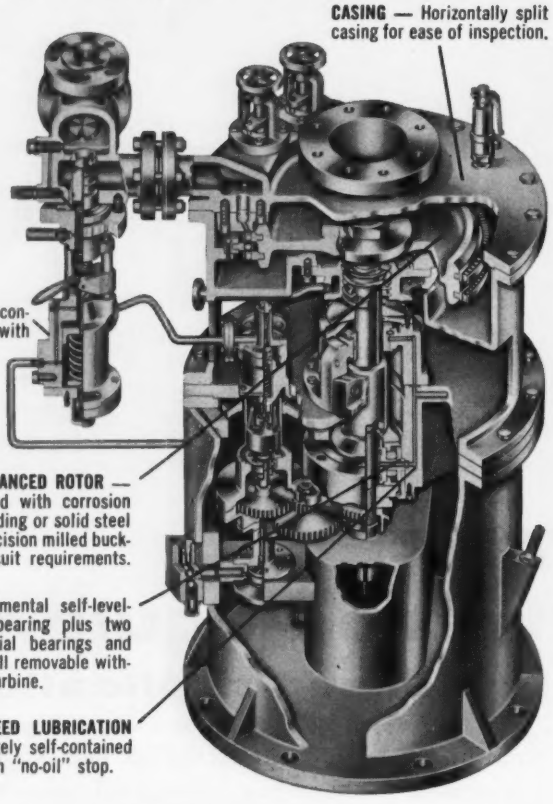
INFILCO Incorporated
General Offices:
Tucson, Arizona

Field Offices throughout the United States and other countries

For more facts circle 292 on Reader Service card, p 125

NEW Whiton VERTICAL TURBINE

Type BHBSV for Vertical Pump Drives



CASING — Horizontally split casing for ease of inspection.

SPEED CONTROL — Oil constant speed governor with overspeed stop.

DYNAMICALLY BALANCED ROTOR — Either steel forged with corrosion resistant steel blading or solid steel one piece with precision milled buckets available to suit requirements.

BEARINGS — Segmental self-leveling type thrust bearing plus two babbitt lined radial bearings and shaft packing — all removable without dismantling turbine.

FORCED FEED LUBRICATION — Completely self-contained system with "no-oil" stop.

The Whiton Vertical Turbine is extremely versatile, compact and dependable . . . ideal for vertical pump drives and other similar applications. The vertical design requires minimum installation space and allows great freedom of location. Simplicity of design and construction results in ease of operation and servicing.

With this vertical turbine added to the line, Whiton's vertical and horizontal steam turbines offer a broad range of power supply applications. Complete data on the new vertical turbine and others available on request.

MAXIMUM OPERATING SPECIFICATIONS	
POWER	to 1000 HP
SPEED	to 8500 RPM
STEAM PRESSURE	to 1250 PSIG
STEAM TEMPERATURE	to 1050° FTT

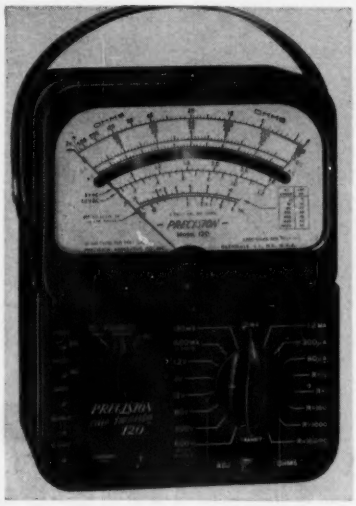
Whiton SINCE 1856

THE WHITON MACHINE COMPANY
NEW LONDON, CONNECTICUT

also permits smaller machine-tool transmissions because it gives more torque for its size.

Closed flux path through hardened steel laminations eliminates need for adjusting air gap. Stationary magnetic field does away with slip rings and brushes. The *EC-S* units are available in five sizes with torque ratings from 14 through 290 lb per ft.—I-T-E Circuit Breaker Company

Just circle key numbers on the Reader Service card, page 125, to get complete product story



Improved multimeter

20 • Mirrored scale to eliminate parallax, dc polarity-reversing switch and wider ac and db frequency response are features of this improved V-O-M. *Model 120* retains sensitivity of 20,000 ohms/volt dc and 5000 ohms/volt ac. The 59 ranges include an extra-low resistance range, an extra-low voltage range and an extended low current range.—Precision Apparatus Company, Inc

Hydraulic fluid

35 • All-synthetic fluid is said to combine low cost with the extreme fire resistance and lube properties of a premium oil. *Pydraul A-200* is available at a tankcar price of $2.85 a gallon.

A formulated compound base on halogenated hydrocarbons, fluid has high compression resistance, excellent lubricity and stability and indefinitely extended service life, ac-

When is the first cost the last cost?

One way to find out is to examine the service records of steam trap installations. Start with a new installation, then learn how long the traps remained in service before they had to be replaced.

At replacement time, was the same brand specified? Or was it found to be inadequate, and a better trap substituted? If substitution was made, why didn't the buyer choose the better brand in the first place?

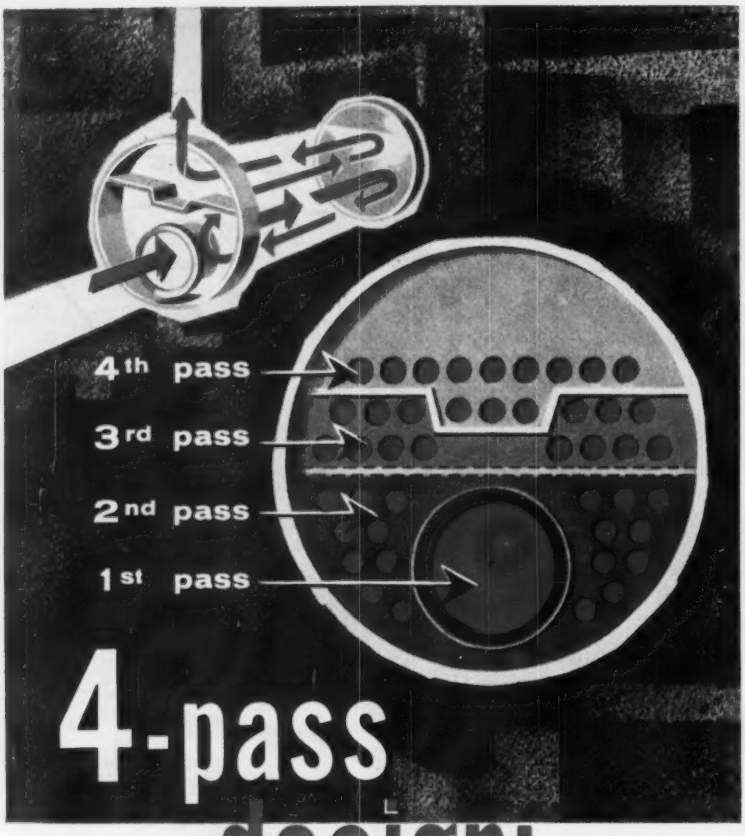
First cost is last cost only when useful service life, not initial price, is the primary consideration. ST-101

NICHOLSON

OF WILKES-BARRE

W. H. Nicholson and Co. • 10 Oregon Street • Wilkes-Barre, Pa.
Distributors in all principal cities

For more facts circle 294 on Reader Service card, p 125



4-pass design:

High fuel-to-steam efficiency for greater fuel economy

EVERY CLEAVER-BROOKS boiler has 4-pass fire tube construction — to scrub more heat from the flame. Maintains high flue-gas velocity... to provide right conditions for optimum heat transfer. This is just one of the Four Design Standards that make pre-engineered Cleaver-Brooks boilers your best packaged-boiler buy.

Other Design Standards

5 SQ. FT. OF HEATING SURFACE per boiler horsepower — prolongs boiler life, assures greater efficiency and lower maintenance.

FORCED DRAFT supplies air for efficient combustion, regardless of draft conditions. Easiest to maintain of all air-control methods.

UPDRAFT CONSTRUCTION — Low furnace keeps hottest combustion gases well below water level for safety's sake.

This exclusive combination of Design Standards is the key to the superiority of Cleaver-Brooks packaged boilers, 15 to 600 hp, 19 sizes, 130 models; steam or hot water; oil, gas or combination oil/gas fired.

For all the facts, call your boiler man from Cleaver-Brooks or write Cleaver-Brooks Company, Dept. G, 301 E. Keefe Ave., Milwaukee 12, Wisconsin.

Cleaver Brooks®

ORIGINATOR AND LARGEST PRODUCER OF PACKAGED BOILERS

Equipment news

Begins on page 140

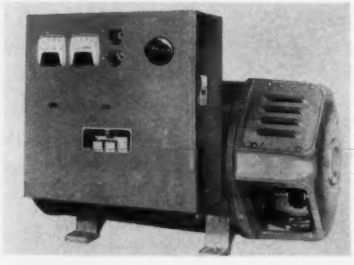
cording to the maker. It is compatible with other all-synthetic hydraulic fluids.—Monsanto Chemical Co

Splash-bar support

54 • Cooling-tower-filling splash bars are now supported by molded grids fabricated of glass-fiber reinforced polyester resin. Supports are noncorrosive, immune to rot and decay. Used in cross-flow towers they are said to extend service life and reduce maintenance cost.

Splash-bar installation is permanently level, preventing water channeling and loss of performance; safety factor is 30:1, according to the manufacturer. Supports are standard equipment on firm's cross-flow cooling-tower line.—The Marley Co

Just circle key numbers on the Reader Service card, page 125, to get complete product story



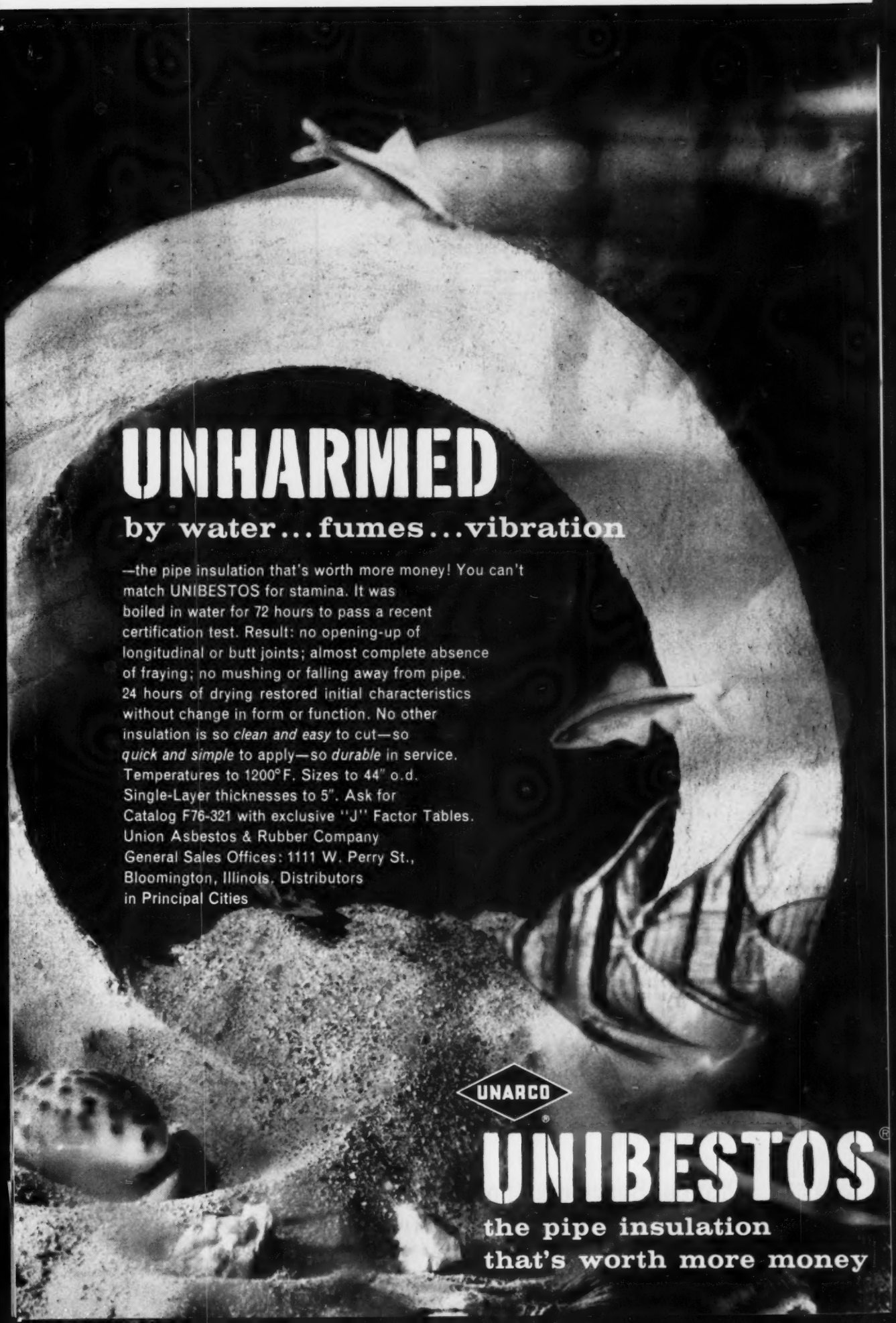
Integrated battery charger

10 • Constant-voltage charger has generator, motor and control panel integrated into one unit, saving up to 42% in cost and 34% in floor space needed.

Models use diverter-pole arma-

For more facts circle 295 on Reader Service card, p 125

circle 296 on Reader Service card, p 125 ➤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by water...fumes...vibration
—the pipe insulation that's worth more money! You can't match UNIBESTOS for stamina. It was boiled in water for 72 hours to pass a recent certification test. Result: no opening-up of longitudinal or butt joints; almost complete absence of fraying; no mushing or falling away from pipe. 24 hours of drying restored initial characteristics without change in form or function. No other insulation is so *clean and easy* to cut—so *quick and simple* to apply—so *durable* in service. Temperatures to 1200°F. Sizes to 44" o.d. Single-Layer thicknesses to 5". Ask for Catalog F76-321 with exclusive "J" Factor Tables. Union Asbestos & Rubber Company General Sales Offices: 1111 W. Perry St., Bloomington, Illinois. Distributors in Principal Cities
UNARCO
UNIBESTOS®
the pipe insulation that's worth more money

I wish we had more personnel and time to prepare this study for a new power plant and site.

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Design and Consulting Engineering Services. Pioneer has specialized in designing power plants for 57 years. It offers design service for fossil fuel, hydro and atomic plants. It will also assist in forecasting load growth, in site selection, in purchasing and expediting of equipment and in supervising construction. Pioneer's other services include substation, transmission and distribution studies and design.

Services in Regulatory Matters. Pioneer offers its services in all phases of Federal, State and Local regulation including the rate base, depreciation analysis, cost of service studies, market analysis, certificate proceedings and rate of return.

Corporate Services. Pioneer's services in corporate matters include business and management engineering advice, financial, accounting and tax counsel and insurance and pension plans and programming. It maintains a complete stock transfer, ledger and dividend disbursement service.

NEW!
On your letterhead, write for 40-page booklet, "Pioneering New Horizons in Power". Describes Pioneer's engineering services, and corporate services, from financing to operation.

57 YEARS

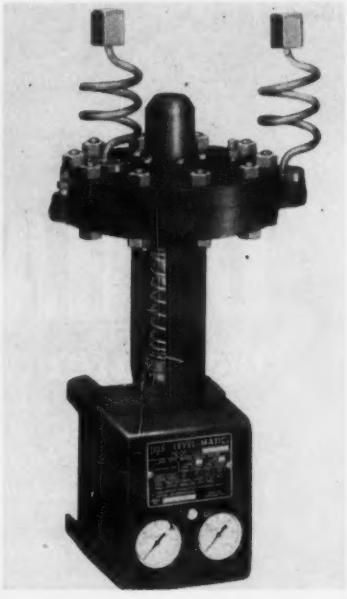
Pioneer Service & Engineering Co.

231 SOUTH LA SALLE STREET, CHICAGO 4, ILLINOIS.

Equipment news

Begins on page 140

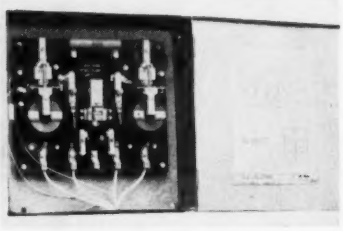
ture design. Electrical loads beyond safe capacity of generator are automatically shifted to the battery.—The Electric Storage Battery Company, Exide Industrial Div



Liquid-level control pilot

49 • Pilot features an adjustable proportional band. A single-knob adjustment lets the band set while system is in operation without affecting liquid-level set point. Unit uses differential-pressure sensing method and is said to be unaffected by surface turbulence. Only two connections to vessel are needed.—Leslie Co

Just circle key numbers on the Reader Service card, page 125, to get complete product story

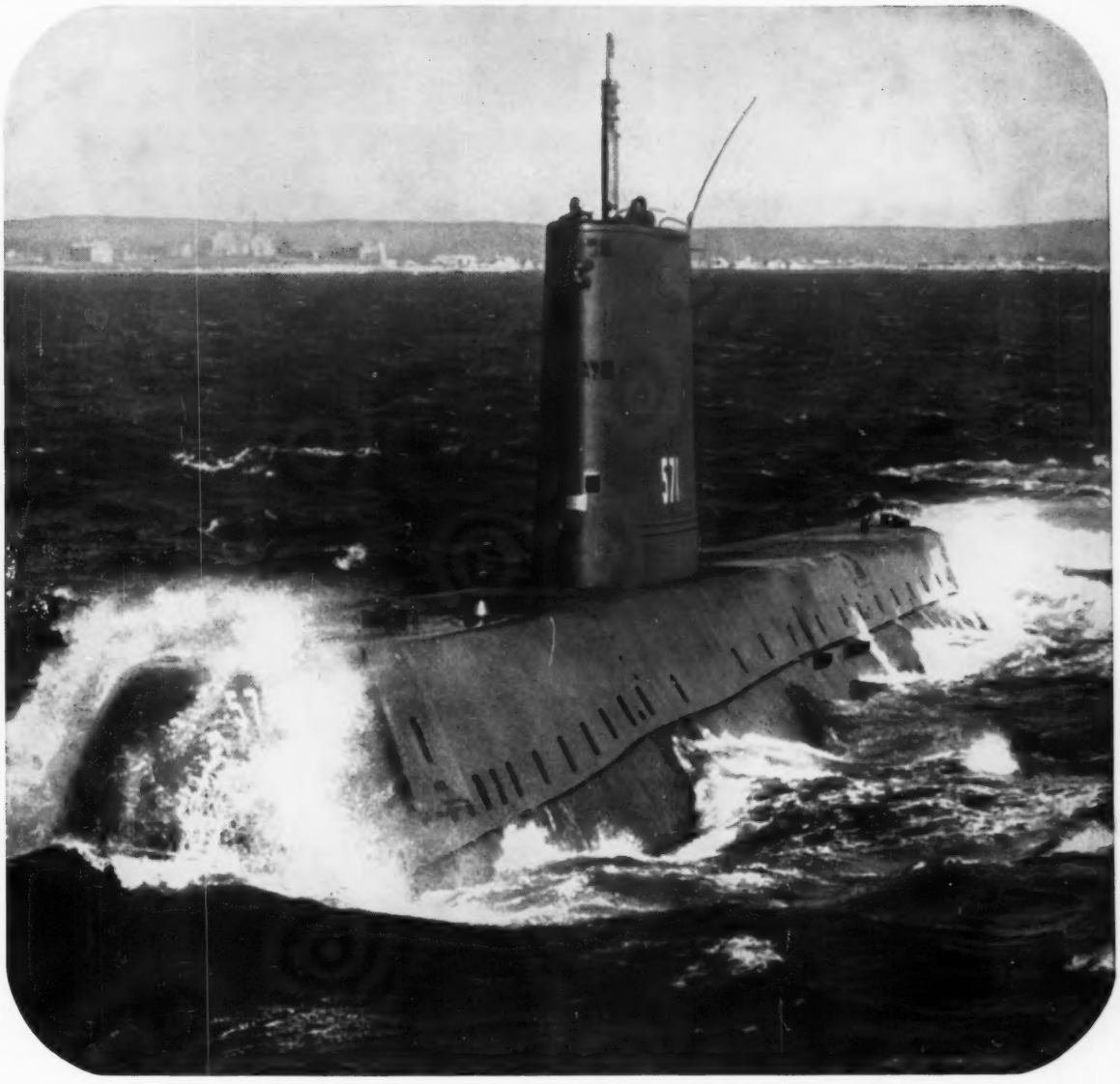


Load demand system

11 • Automatic system *FAC-100* is for use with electric plants up to 4500 w. Unit automatically starts

continued on page 166

ION EXCHANGE RESINS serve the new atomic navy



In Atomic Powerplants on Nuclear-Powered Submarines, AMBERLITE Ion Exchange Resins Remove Radioactive Contaminants

Because water impurities become radioactive when exposed to radiation, cooling water which passes through reactors on Navy atomic submarines is treated by passage through beads of specially-developed, highly active grades of AMBERLITE Ion Exchange Resins. These resins remove all metallic ions from the water and also are used to control pH of coolant within safe limits. In addition, they have the important advantage of concentrating in small volume the radioactive materials which they remove from water.

These special cation and anion exchange resins for reactors are usually supplied in an intimate mixture for use in MONOBED units. Complete technical information on special Nuclear Grade AMBERLITE Ion Exchange Resins and their uses will be sent promptly on request. Consult your engineering company experienced in water conditioning on how AMBERLITE resins may serve you.

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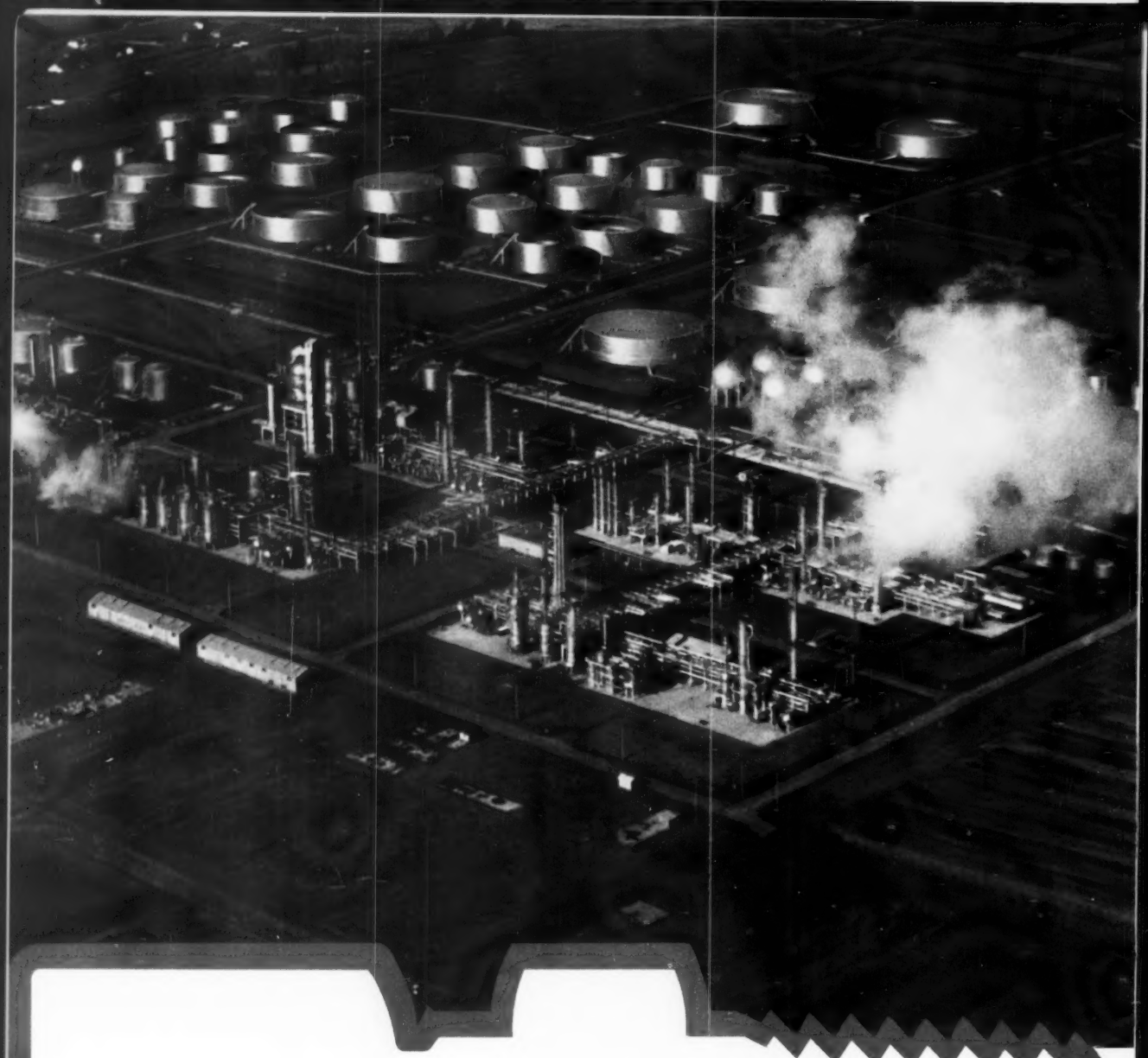
Chemicals for Industry

ROHM & HAAS COMPANY

THE RESINOUS PRODUCTS DIVISION

Washington Square, Philadelphia 5, Pa.

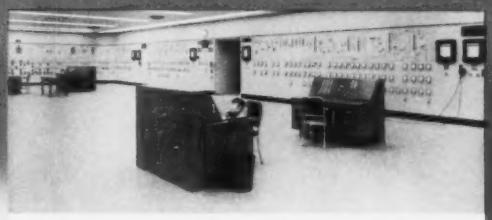


NO COMPROMISE WITH QUALITY IN THIS MODERN PETROLEUM PLANT

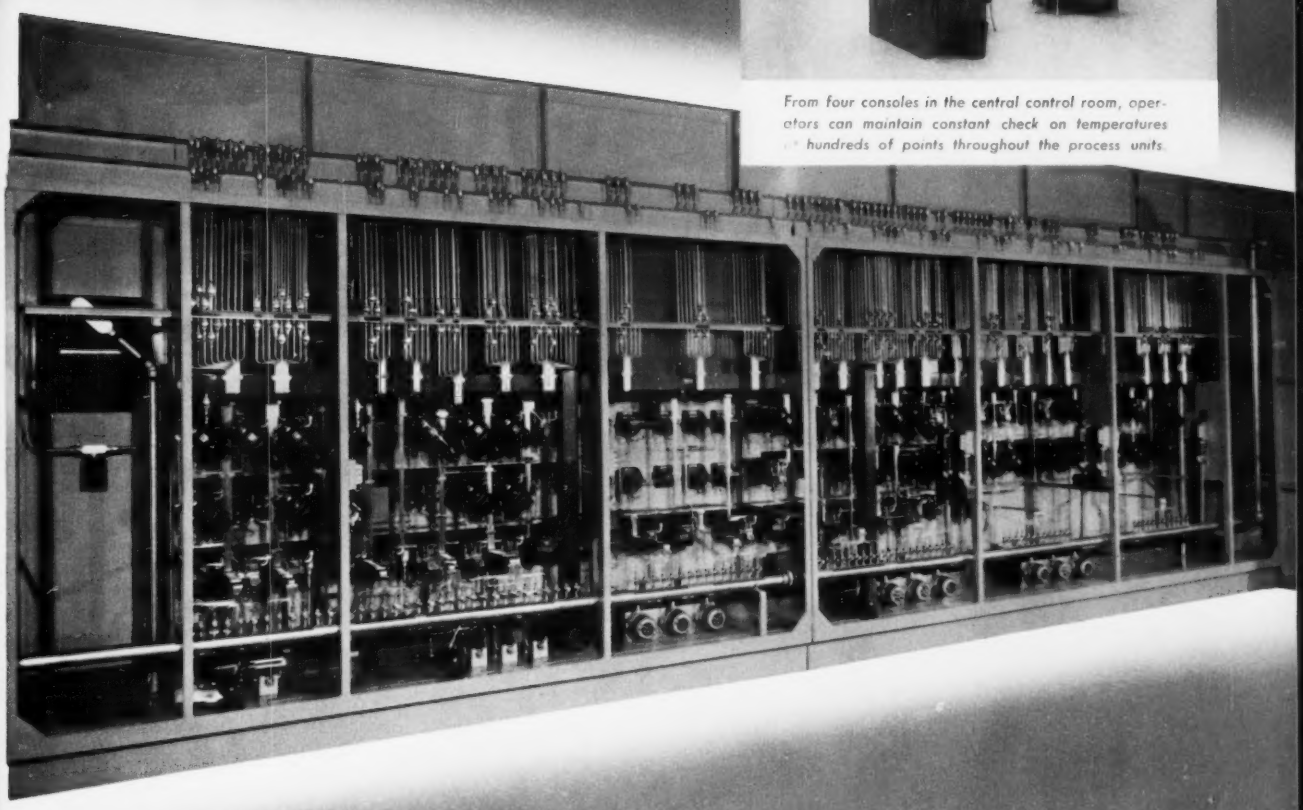
The capacity of this new Texaco Refinery at Anacortes, Washington, is 45,000 barrels of crude oil per day, processed into a full range of finished Texaco quality products . . . high octane and regular gasoline, jet fuel, burner oil, kerosene, diesel oil, bunker fuel and propane gas.

Quality control is the watchword here . . . with automation and instrumentation bearing the major responsibility. More than 30,000 Swagelok Tube Fittings were used for instrumentation and steam tracer lines throughout the plant, including over 12,000 for the panel boards in the control center. In keeping with their high standards of quality in panelboard manufacturing, Swanson Engineering & Manufacturing Co. selected Swagelok Tube Fittings to secure precision control with torque-free seals that are absolutely tight. In the science of sealing, Swagelok Tube Fittings approach the ultimate desired by designers today.

CREDITS: *Owner: Texas Company. Complete engineering procurement and construction: Bechtel Corporation, San Francisco, Calif. Panel Boards for Central Control Room manufactured by Swanson Engineering & Manufacturing Co., Inglewood, Calif.*



From four consoles in the central control room, operators can maintain constant check on temperatures at hundreds of points throughout the process units.



This view of back of panel board illustrates the outstanding craftsmanship in design and construction by SWANSON ENGINEERING & MANUFACTURING CO.

In this great new Texaco Refinery Swagelok Tube Fittings stand guard against pressure, vibration and torque

In the refining of 45,000 barrels of crude per day at the new Texaco Refinery, obviously all of the units in the process control line must bear a big load of trust in performance.

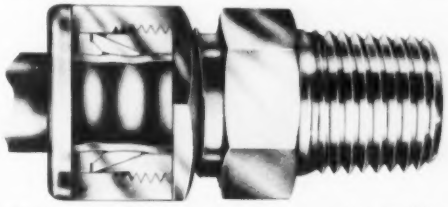
The Swagelok Tube Fittings used in the plant and control panels represent 30,000 trusts in dependable performance. Their design is unique, based on the principle that

nothing is quite so good as the finest that man's ingenuity can create and that precision machines can produce!

The new Texaco Refinery at Anacortes, Washington, is one of many different industries using Swagelok Tube Fittings for trouble-free, leak-proof operation.

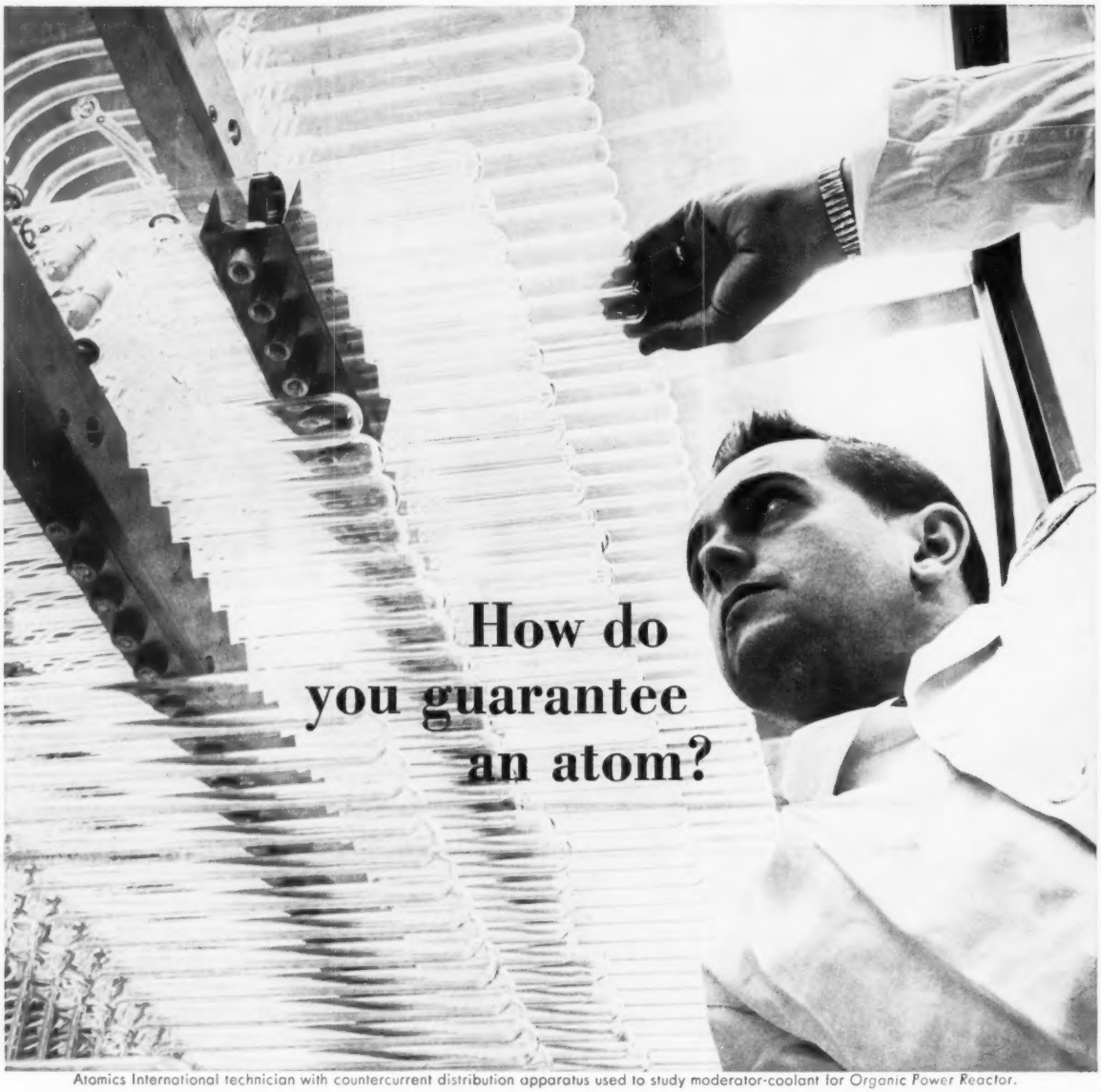
Crawford Fitting Company
884 East 140th St., Cleveland 10, Ohio
Crawford Fittings (Canada) Ltd., Niagara Falls, Ontario, Canada

Swagelok®



Swagelok Tube Fittings are available in any machinable metal or plastic, in sizes for 1/16" through 1" O.D. tubing.

Printed in U.S.A.



Atomics International technician with countercurrent distribution apparatus used to study moderator-coolant for Organic Power Reactor.

Begin with the knowledge of experienced scientists... conduct a seven-year research and development program ...collect a wealth of solid operating experience. Result: GUARANTEED PERFORMANCE of a nuclear power reactor, designed by Atomics International to help meet the world's power needs.

This is the ORGANIC POWER REACTOR—outgrowth of research and development on the organic system and operation of the Organic Moderated Reactor Experiment (OMRE) conducted by Atomics International for the U.S. Atomic Energy Commission.

Outstanding advantages of the ORGANIC POWER REACTOR: Low capital investment • Low cost operation • High inherent safety and flexibility • Reliability resulting from

- **Non-corrosive moderator coolant**
- **Low pressure system**
- **Conventional, off-the-shelf components and materials**
- **Easy access during operation**

Atomics International is ready to furnish complete ORGANIC REACTOR electric power plants, including fuel elements, in a wide range of power levels. An experienced field staff will assist with initial plant operation, personnel training and maintenance procedures.

For details contact: ATOMICS INTERNATIONAL, Canoga Park, California, U.S.A. Cable address: ATOMICS.

ATOMICS INTERNATIONAL
A DIVISION OF NORTH AMERICAN AVIATION, INC.
PIONEERS IN THE CREATIVE USE OF THE ATOM

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Each of these men is a highly-trained technical specialist in the field of heat transfer. If you have a problem concerning such things as design, surface area, corrosion, alloy selection, where and when it is advantageous to use integrally-finned tube, etc.—don't hesitate—give the one nearest you a call. You can depend fully on his heat transfer knowledge, particularly where tubing is concerned.

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EXPORT DEPT. 13 E. 40TH ST., NEW YORK 16, N.Y.

For more facts circle 301 on Reader Service card, p 125

MORE STEAM-FASTER AT LOWER COST

COMPAK water tube boilers are available as completely packaged forced draft units for low or high pressure service in 22 sizes from 12 to 750 HP.

Faster steaming is only one of the many superior features of INTERNATIONAL COMPAK WATER TUBE PACKAGE BOILERS.

No matter what you're looking for in a boiler — low cost . . . long life expectancy . . . high efficiency . . . low maintenance . . . easy cleaning . . . automatic, foolproof operation, etc. — it will pay you to take a closer look at the COMPAK.

Get full details from your INTERNATIONAL DISTRICT REPRESENTATIVE or write for Bulletin 1400 today.

IBW BOILER BUILDERS SINCE 1886

THE INTERNATIONAL BOILER WORKS CO.

Steel Firebox Heating & Power Boilers Low & High Pressure Water Tube Package Boilers • International-LaMont Forced Recirculation Generators • ASME Code Pressure Vessels & Welded Products.

930 Spruce St. East Stroudsburg, Pa.

Manufactured and sold in Canada under agreement with CANADIAN VICKERS LTD. Montreal, P. Q.

For more facts circle 302 on Reader Service card, p 125

When this stack goes up

your costs go down

A. O. Smith *Permaglas*® smokestacks—glass-protected inside and out . . . are virtually impervious to condensate corrosion

Write for free bulletin SS-202 illustrating how to get greater return from your stack investment

A. O. Smith Corporation, Dept. P-69, Milwaukee 1, Wis. Please send me a copy of the Permaglas Smokestack Bulletin No. SS-202.

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Through research . . . *a better way*

A.O.Smith CORPORATION

PERMAGLAS SMOKESTACK SALES PROCESS EQUIPMENT DIVISION MILWAUKEE 1, WISCONSIN

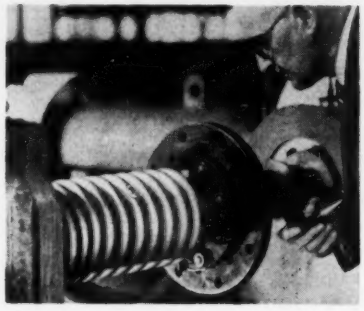
Equipment news

Begins on page 140

electric plant, turns off power when it's not needed. Fuel savings are said to run up to 50%, and generator life span is increased.

System can be used for standby control, when equipped with an automatic line transfer switch.—Pacific Mercury Company

Just circle key numbers on the Reader Service card, page 125, to get complete product story



Bellows expansion joints

31 • Used for district heating and other steam and hot-water lines, flexible piping components will absorb thermal expansion and contraction. They will also avert excessive stresses from vibration or misalignment in short piping connections.

Initial production of stainless-steel joints will be in 3- to 30-in. nominal pipe sizes for applications up to 275 psi, 750 F. A 4-in. 10-convolution unit is undergoing traverse testing, above. — Chemetron Corporation, Tube Turns Div

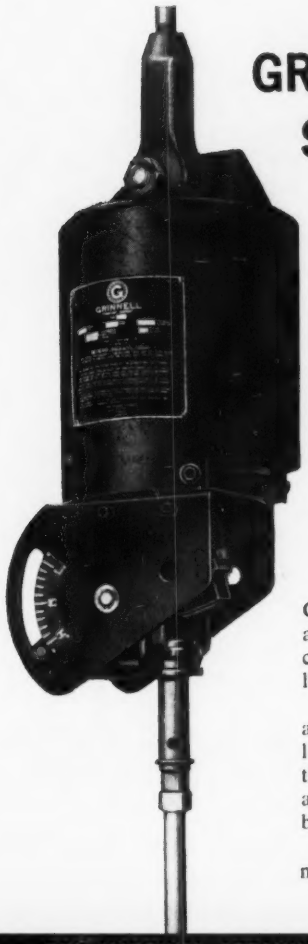
Multipurpose lube

19 • Premium-quality lube can be applied to 90% of ball and roller-bearing installations, according to maker. It gives good results with plain or needle bearings and on rotating and sliding surfaces.

No. 88 is a high film-strength lithium-base product with excellent water-repellent properties. It is unaffected by exposure to damp atmospheres or water.

The lube has powerful absorptive properties, manufacturer states. It is smooth, nonfibrous, homogeneous and odorless. Operating temperature is 0 to 275 F. Six densities range from medium to very light.—Keystone Lubricating Co

For more facts circle 303 on Reader Service card, p 125



GRINNELL CONSTANT SUPPORTS...

2 BASIC DESIGNS...

11 DIFFERENT METHODS OF ATTACHMENT

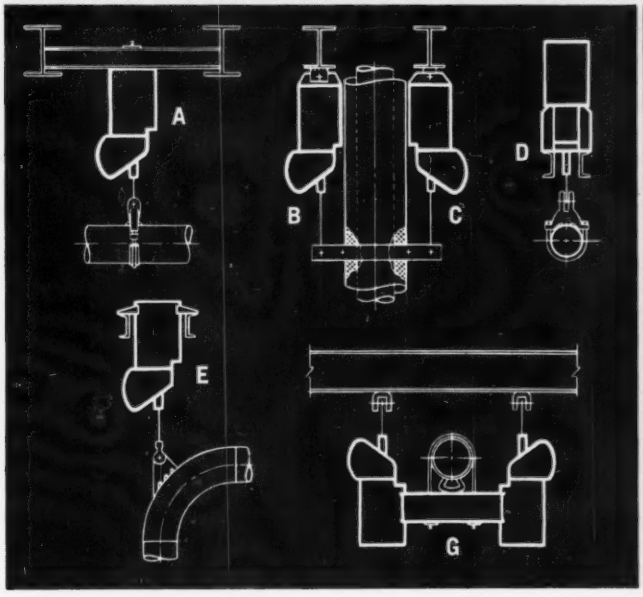
Grinnell Constant Supports are available in a range of sizes to provide capacities for loads from 27 lbs. to 57,500 lbs., with travels up to 16 inches.

Both vertical and horizontal hangers are designed to operate in extremely limited space. In the selection of types, there is a choice of 11 methods of attachment to structures—either above, between, or below supporting steel.

Grinnell Constant Supports provide mathematically perfect load support throughout all positions of travel . . . also a full 70 percentage points of adjustability is built into them. No less than 10% of this adjustability is allowed either side of calibration for plus or minus change in load. Field readjustments are easily made by turning a single load adjustment bolt.

Call on Grinnell's Pipe Suspension Department for help with your pipe suspension problems. Grinnell Company, Providence 1, Rhode Island.

FOR VERTICAL ATTACHMENT



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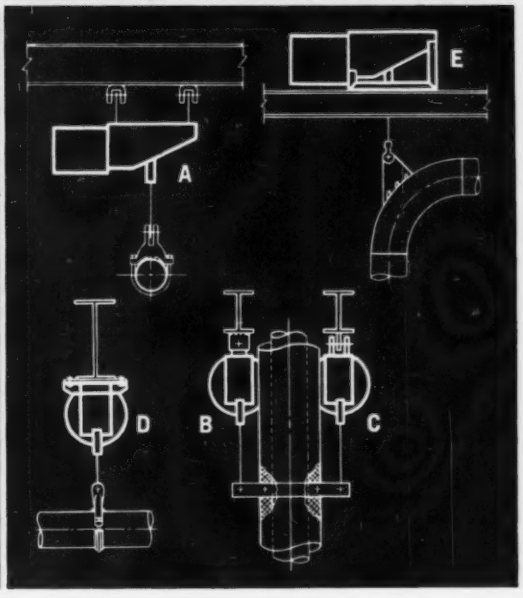

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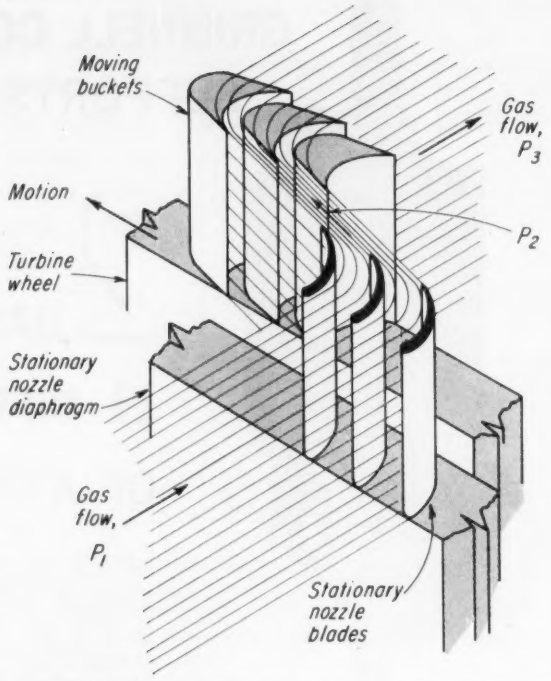
AMERICA'S No. 1 SUPPLIER OF PIPE HANGERS AND SUPPORTS

For more facts circle 304 on Reader Service card, p 125

THERMO REFRESHER NO. 28

By B G A SKROTZKI, Associate Editor



1 Gas-turbine nozzles direct gas flow to enter moving buckets tangentially. Slower buckets turn jets to develop work force

The Laws of thermodynamics can be applied to a machine on an overall basis or just to parts of it in trying to understand its operating principles and limitations. Here we begin to analyze turbine operation and learn . . .

How nozzles handle hot-gas flow

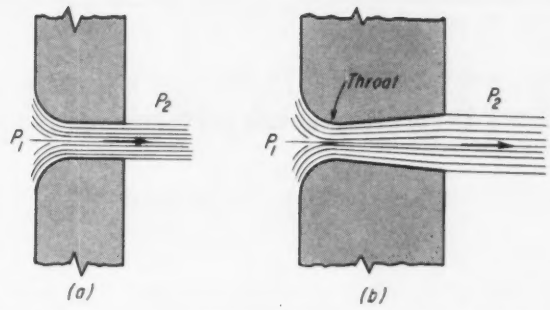
We have studied the gas-turbine engine as an energy-converting device without knowing how the components work internally. Now let's look at the innards; first the turbine, later the compressor. Fig. 1 shows a few of the principal elements of a gas turbine that change the internal energy of the gas into mechanical shaft work.

Gas flow. Hot pressurized gas at P_1 enters the spaces between the arc-shaped blades of the stationary nozzles and flows to the space ahead of the moving buckets at a lower pressure P_2. The nozzles direct the gas flow to impinge on moving buckets mounted on turbine wheel or disk. Stationary nozzles may cover only part of the rim of the stationary nozzle diaphragm, the remainder being blocked closed. But the moving buckets completely cover rim of turbine wheel.

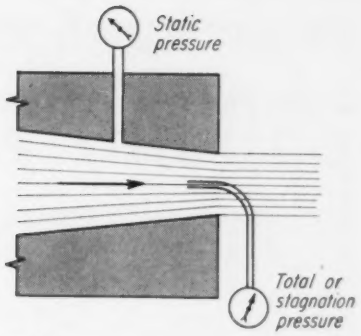
Nozzles reorganize the random motion of the gas molecules so that they largely move in a common direction and form a high-speed jet of gas. Jet is made to pass between the slower moving buckets in a prearranged pattern so that it produces a force on the buckets and does mechanical work on the turbine wheel carrying the buckets. The jets flow through passages between the moving buckets and turn to leave at about right angles to buckets' motion at a pressure P_3.

Energy transfer. In passing through the bucket passages the jets give up much of their kinetic energy by impacting the buckets and increasing their momentum. If you're rusty on impact and momentum see Part 6, Feb 1957, pp 88-89. Depending on bucket design, $P_3 = P_2$ or P_3 may be less than P_2.

Fig. 1 shows two distinct energy processes in turbines: (1) changing internal energy of the gas to kinetic energy of the gas mass by persuading the gas molecules to flow in a given direction through the nozzles and (2) changing kinetic energy of the gas to mechanical shaft energy in the moving buckets by transferring momentum from gas molecules to the buckets. Nozzles and buckets need to be placed in proper relation to each other, but otherwise the two processes are largely independent as far as energy conversion is concerned. Let's study each of these two processes in more detail.



2 (a) Simple converging nozzle has parallel-wall exit to form a smoother jet. (b) Converging-diverging nozzle does unique job



3 Static pressure measured at right angles to flow, stagnation pressure parallel

Nozzles. In Part 23, Jan 1959, p 130 we showed that the steady-flow energy equation for flow through nozzles reduces to:

$$\frac{w}{2gJ}(v_2^2-v_1^2) = H_1-H_2 \qquad (1)$$

where w = rate of flow, lb per sec; v = gas jet speed, ft per sec; H = gas enthalpy, Btu per lb.

In Part 24, Feb 1959, pp 145-146 we learned about the relation between flow and the pressure ratio across the nozzle. Now let's do some mathematical analysis of these relations and speculate some more about molecular behavior in flowing gases.

While Fig. 1 shows the practical way of building nozzles for turbines, a more fundamental way of studying nozzle behavior finds how gas flow behaves in passing through a simple hole as in Fig. 2. The converging nozzle in Fig. 2*a* has a smooth curved entrance section followed by a parallel-walled section; this can be used for the higher range of pressure ratios across the nozzle, P_2/P_1. For lower pressure ratios we'll find that the entrance section has to be followed by a flared section to form the converging-diverging nozzle of Fig. 2*b*. The narrowest cross section is called the throat of the nozzle.

As gas flows through a nozzle it passes from a higher to a lower pressure region. But what is the pressure of the gas flow? It depends on how and where we measure it. Usually, because the gas molecules diffuse into the nozzle opening from all directions, the gas pressure at inlet will be the same as the source, P_1.

Tapping the walls of a nozzle we find that pressure drops as the nozzle cross section changes. Pressure measured through an opening at right angles to the flow is called *static pressure*. We assume that this pressure describes the state of the gas at that cross section, Fig. 3.

Stagnation states. Aiming the pressure tap upstream, Fig. 3, measures the *total* or *stagnation pressure*. If there are no frictional losses in the nozzle stagnation pressure stays constant along the length of the nozzle from inlet to outlet.

In defining stagnation pressure we assume that the gas slug entering the pressure tap comes to rest, compressing itself at constant entropy. Following gas flow diverted by the stopped gas in the tap keeps the slug compressed by molecular impingement. Initially this moving gas slug has an enthalpy H_1 and a kinetic energy $v_1^2/2gJ$. When it comes to rest in the pressure gage it has only an enthalpy H_o, called the *stagnation enthalpy*. Since no energy has been added or subtracted during this compression process:

$$H_1 + v_1^2/2gJ = H_o \qquad (2)$$

In the usual case the velocity of approach of the gas entering a nozzle is so small that $H_1 = H_o$ and stagnation pressure = $P_o = P_1$. As the velocity of approach rises, however, H_o and P_o become larger than H_1 and P_1.

The same line of reasoning applies to the *stagnation temperature*. Since $H_1-H_o = c_p(T_1-T_o)$ it follows that:

$$T_1 + v_1^2/2gJc_p = T_o \qquad (3)$$

Nozzle pressures. A nozzle develops gas velocity by inducing the molecules leaving the source to travel in a more uniform direction as they go through the nozzle. Most gas molecules in the nozzle at any instant travel in the general direction of the gas mass flow. Some of them impact the nozzle walls to produce the static pressure. But since the majority travel in the direction of flow, stagnation pressure will be higher than static pressure, assuming they all travel at the average velocity.

As we reduce gas flow to zero by raising the outlet pressure more and more of the molecules take on random directions and hit the walls to raise the static pressure with steady stagnation pressure. At zero flow the static and stagnation pressures become equal.

Nozzle flow. In computing nozzle flows we must recognize that the mass rate of gas flow under steady conditions remains constant at all cross sections of the nozzle, then:

$$w = \frac{A_1v_1}{V_1} = \frac{A_2v_2}{V_2} = \frac{A_3v_3}{V_3} = \text{etc} \qquad (4)$$

where A = nozzle cross section, sq ft; v = gas flow velocity, ft per sec; V = gas specific volume, cu ft per lb; w = gas flow, lb per sec.

The velocity of the jet leaving the nozzle plays an important part in turbine design; it can be computed from equation (1) by transposing and assuming a flow rate of 1 lb per sec:

$$v_2 = \sqrt{2gJ(H_1-H_2) + v_1^2} \qquad (5)$$

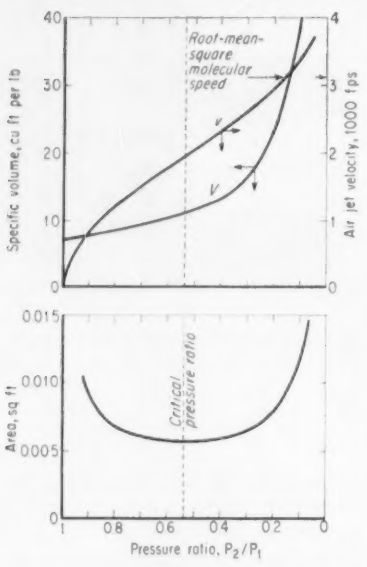
The static pressures can usually be measured most easily so we transform equation (5) to a more convenient form. First we'll assume $v_1 = 0$ and substitute numbers for gJ, then:

$$v_2 = 223.8\sqrt{H_1-H_2} \qquad (6)$$

$$H_1-H_2 = c_p(T_1-T_2) \qquad (7)$$

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} \qquad (8)$$

Equation (8) applies to a constant-entropy expansion of the gas while it



4 All factors controlling nozzle gas flow vary with the overall pressure ratio

Theoretical nozzle performance

Air flow = 1 lb per sec
P_1 = 100 psia = 14,400 psfa
T_1 = 1900°R k = 1.33

P_2/P_1	P_2 psia	V_2 cu ft/lb	v_2 ft/sec	A_2 sq ft
1.0	100	7.03	0	—
0.9	90	7.61	832	0.00915
0.8	80	8.31	1203	0.00691
0.6	60	10.32	1783	0.00579
0.54	54	11.17	1945	0.00574
0.4	40	13.44	2333	0.00576
0.2	20	23.58	2967	0.00795
0.1	10	39.72	3415	0.01164

flows through the nozzle; this usually holds nearly true. Then transforming equation (7):

$$c_p(T_1-T_2) = c_pT_1\left(1-\frac{T_2}{T_1}\right)$$

$$= c_pT_1\left[1-\left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}\right] \qquad (9)$$

Substituting in equations (6), (7):

$$v_2 = 223.8\sqrt{c_pT_1\left[1-\left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}\right]} \qquad (10)$$

To complete our tools for nozzle performance analysis we have to recall that for a constant-entropy expansion:

$$\frac{V_2}{V_1} = \left(\frac{P_1}{P_2}\right)^{\frac{1}{k}} \qquad (11)$$

With equations (4), (10) and (11) we're ready to analyze what happens to a perfect gas as it flows through a nozzle. First we'll assume we have air as our source with P_1 = 100 psia = 14,400 psfa; T_1 = 1900°R; k = 1.33; R = 53.3; V_1 = 7.03 cu ft per lb. The approach velocity v_1 = 0 so in effect $P_1 = P_0$; this holds for all the properties.

Next we'll find the properties of the gas, its velocity and the cross-sectional area the nozzle must have for a flow of 1 lb per sec at successively lower static pressures. We conveniently express this as a pressure ratio P_2/P_1.

Table, above, lists the calculation results and Fig. 4 shows the variation of specific volume, velocity and nozzle cross-sectional area with gas-pressure ratio. At unity ratio with equal pressures at inlet and outlet, velocity is zero, though we can visualize individual molecules drifting erratically from one end to the other in all directions through the nozzle. As the outlet pressure drops more molecules drift toward the lower pressure than the other way to give a net mass flow through the nozzle.

As Fig. 4 shows, the velocity v builds up rapidly at first, with a diminishing rate of increase up to the critical pressure ratio. At less than the critical the rate of increase again rises. We'll talk about the meaning of critical pressure ratio a little later. The continuing rise in v with drop in pressure ratio raises an interesting question. The root-mean-square molecular velocity of air molecules at 1900°R is 3138 fps. Yet equation (10) for zero pressure ratio and 1900°R gives a maximum value of 5175 fps. Obviously the equation doesn't hold for the full range of pressure ratios as plotted in Fig. 4. The molecular velocity corresponds to a pressure ratio of 0.156. This is inconsistent; if the entire gas mass travels at molecular velocity all the molecules must be moving parallel to the axis of the nozzle and none of them can hit the wall to produce a static pressure. But the whole process is complicated by the Maxwell distribution of molecular velocities which plays an important part in not too clear a fashion. Despite these inconsistencies the equation does hold for the higher pressure ratios, at least down to the critical pressure. As we'll see, shock conditions at lower pressure ratios make the inconsistencies largely an academic question.

The specific volume grows at an increasing rate with the drop in pressure ratio, Fig. 4. This follows from the perfect gas equation and assumes that the static pressure and constant entropy expansion properly describes the state of the gas at a given cross section of the nozzle.

Most interesting behavior of nozzle design is the variation in A as the pressure ratio drops, Fig. 4. From infinity at P_2/P_1 = 1 it falls to a minimum at the critical pressure ratio and then grows at an increasing rate for the lower pressure ratios.

If we want to build a nozzle with a uniform pressure drop along its length the shape of the area curve gives us the profile of the nozzle wall section. Fortunately, nozzles need not

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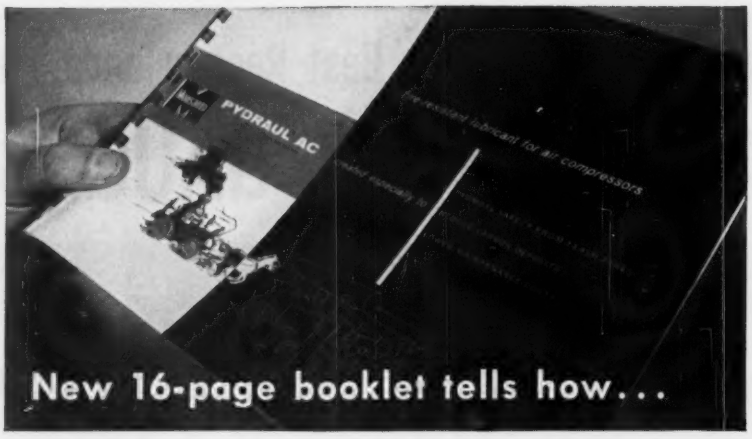

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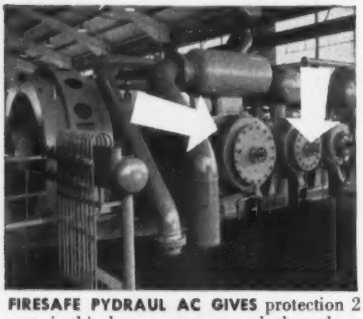

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Gas-turbine nozzles

Continued from page 170

have uniform pressure drops, so we can make them as in Fig. 2. For overall pressure ratios greater than or equal to the critical, we use the converging parallel-wall nozzle with the minimum opening sized to pass the design w for the given P_2/P_1.

For the initial conditions used in the table and Fig. 4 the nozzle cross-sectional area becomes a minimum at $P_2/P_1 = 0.54$. The pressure ratio at which A becomes a minimum is called the *critical pressure ratio.* As we saw in Fig. 2*b* the section with minimum area in a nozzle is called the *throat.*

When overall pressure ratio across a converging-diverging nozzle equals critical pressure ratio or less, pressure at the throat is always the critical pressure. For the same ratio range, flow through the nozzle will be governed by the area of the throat.

While nozzles appear to be very simple devices we'll find that their behavior has some unexpected quirks that require close study for full understanding. Equations of flow will be found to apply to a limited range of pressure ratios, even more limited than we discovered for the v curve in Fig. 4. This behavior must be fully understood so that we can learn the flexibility and limitations of gas and steam turbines.

We'll discuss nozzle flow limitations and shock conditions in nozzles in the next part—in a forthcoming issue.

Environmental chamber for commercial testing on a large scale has been added to American Labs, Fullerton, Calif. It can reproduce an Arctic coldspell or tropic monsoon.

Soviet technical info will now be translated by a Foreign Technical Information Center. Included will be abstracts of all articles from 141 technical journals, available on single-issue or subscription basis.

Pushbutton plants are coming nearer reality, says the ASME. An automatic computer in a southern power plant scans 250 temperatures on bearings, boilers, transformers, sounds an alarm if any are too hot.

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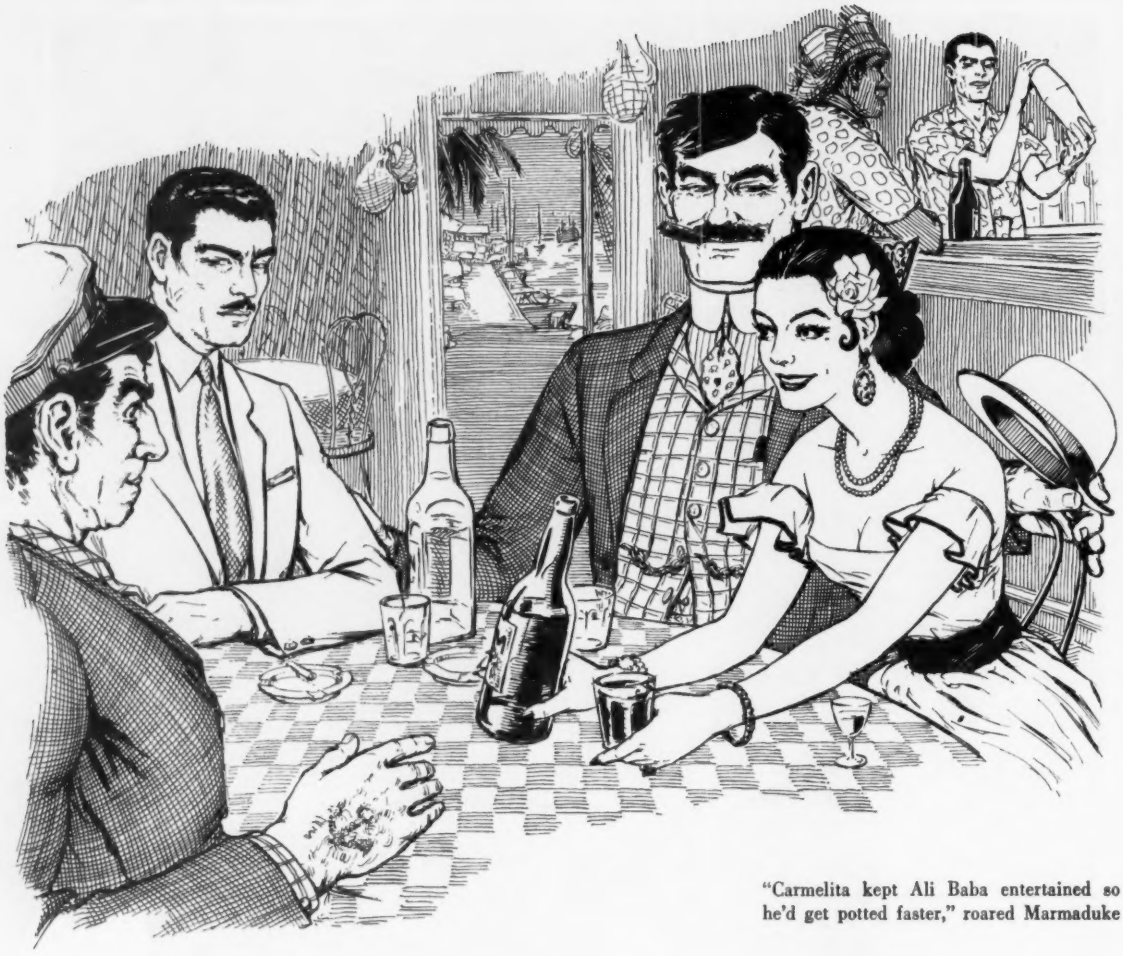


"Carmelita kept Ali Baba entertained so he'd get potted faster," roared Marmaduke

Marmy's vanishing oil

"BILGEWATER on pulling sleight-of-hand tricks in a power plant," roared Marmaduke Surfaceblow at the Bent Propeller Bar last night. "I ran into one of those plant magicians in the Caribbean years ago. When I got through with him his trick vanished into thin air."

That pronouncement stopped the works at the Bent Propeller. All heads turned toward the cantankerous consultant as he towered above his shipmates at the bar. I kept digging into my corned beef and cabbage but tuned in to his wave length—didn't want to miss the fireworks.

Marmy suddenly worked up a vacuum on his fuel pump and ballasted his double bottoms from the bottle of Sandpaper Gin before him. Then he turned toward his audience and again blasted away in his foghorn voice.

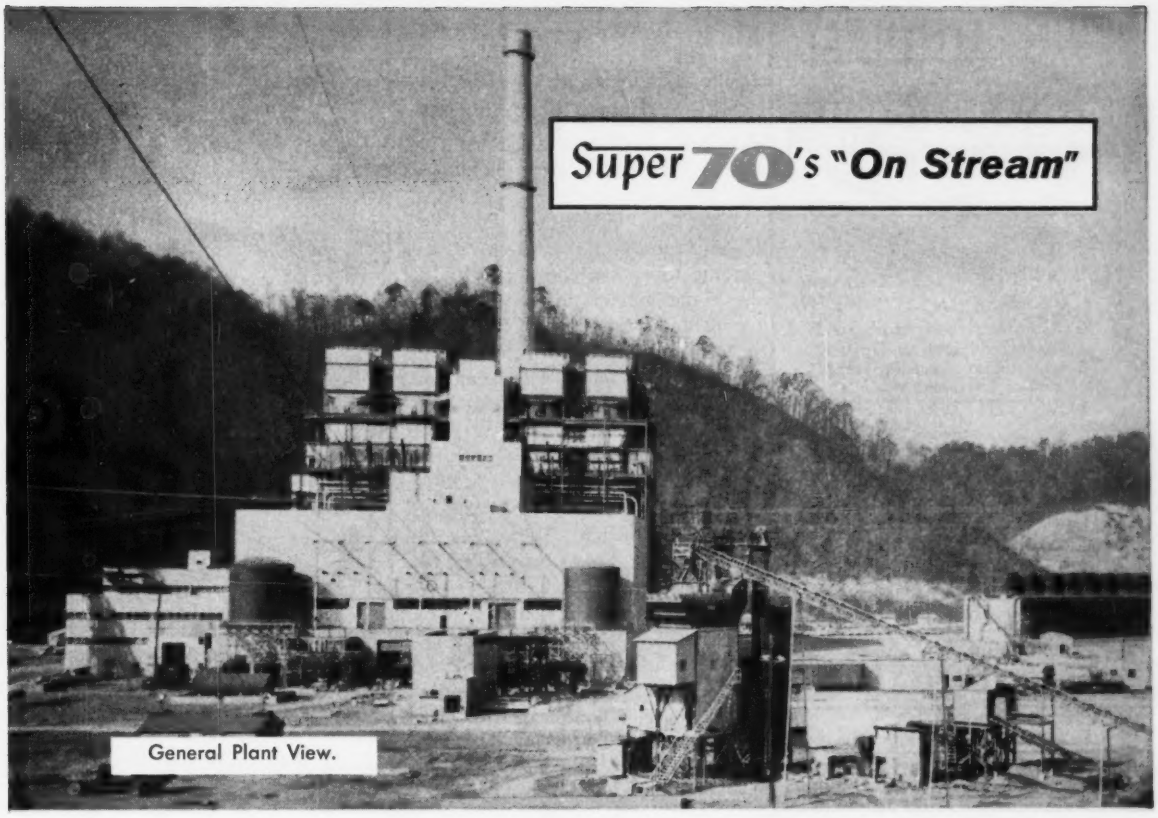
"Back in 1923 I was chief engineer of the Caribbean tramp steam *SS Quaimaro*. She was registered out of Havana and made island ports in the Caribbean Sea. One trip we started girdling Cuba. After making Glenfuegos, Tunas de Azaz and Manzenillo, we pulled into Santiago de Cuba, a wide-open port, at the island's southern end.

"Soon as we'd tied up to the sugar pier that morning I navigated ashore to visit my girlfriend Carmelita Castenada. She ran the popular waterfront hangout known as Carmelita's Cantina, across the street from the utility plant. I knew something was always going on at her place.

" 'Hello Marmy,' yelled a familiar voice as I barged through the door. It was my old shipmate Bill Pender. Bill and I had sailed up and down the Mississippi River years before. He introduced me to his friend, Gustavo Orocovis, superintendent of the local utility.

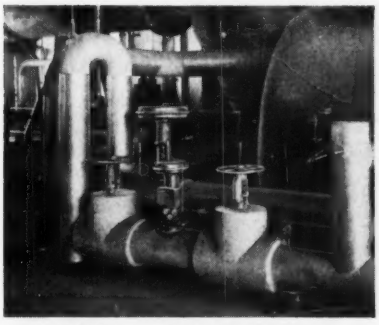
"Bill was in town installing new machinery at the large Bacardi distillery for an American engineering firm. For a few drinks I listened to Orocovis trying to get Bill to drop into his plant to help him spot a fuel-oil mystery that was driving him nuts. Sounded interesting.

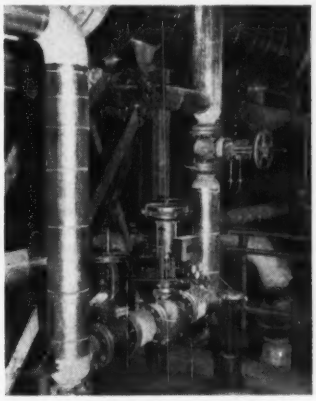
" 'Here's your man,' said Bill, pointing to me. 'I'm



General Plant View.

Clinch River Plant, Units 1 & 2


High Pressure Heater Drain To Deaerator.


Number 4 Heater Level Control Valve.

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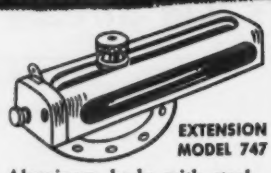
"ON-THE SPOT" EFFICIENCY

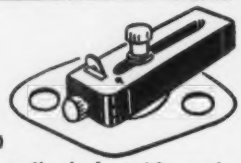
SPEARHEAD GASKET CUTTERS

HAND • TOOLS



EXTENSION MODEL 747

Aluminum body with steel blades and inch and metric scales. Cuts precision round gaskets any size



HANDY MODEL 750

Phenolic body with steel blades and inch and metric scales . . . cuts round gaskets ¼" to 6", odd shapes and straight pieces any size

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. . . for efficient removal and disposal of suspended particles from raw or process water and other liquids

✓ Over 1000 installations
✓ 2" to 48" pipeline sizes
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Write today for Bulletin 500.1P

S.P. KINNEY ENGINEERS, Inc.
CARNEGIE, PENNSYLVANIA

Marmaduke

Continued from page 174

days behind schedule at the distillery, Gustavo. Why don't you let Marmy take a look-see?'

"'We'll be in port for three days loading rum,' I told Orocovis, 'so I've got the time. Besides, I can always use some green stuff when I visit Carmelita here.'

"'OK, Señor,' he said. 'Something is screwy with our fuel consumption. If you find the trouble, maybe I can get a few hundred pesos for you. But I think you'll have to work for that money.'

"'Cheapskate,' yelled Carmelita from behind the bar. 'Marmy is going to spend that dinero on me, so you can give him five hundred pesos. We all laughed at that. But Gustavo agreed.

"'OK,' he said, 'If he can tell me what's wrong without us spending money for new equipment, I'll make it five hundred.' With that settled the party broke up. Bill shoved off for the distillery and Orocovis and I started across the street.

"On the way Gustavo explained they had been burning Bunker C for two years, but their fuel consumption was too high. He felt that either his firemen didn't know how to fire or something was wrong with their fuel-oil equipment.

"Then he made a crack that gave me a clue. Their fuel consumption always skyrocketed the first few days after the oil was delivered. After that it would start going down to normal.

"'You have no problem,' I told him, 'that's caused by shrinkage. Chances are the barge delivers your oil too hot. Then on cooling down it shrinks. So because it cools down right after delivery, your consumption is higher for the first few days.

"'No no, Señor,' he snapped back, kinda hot under the collar. I guess he thought I took him for a jackass. 'I know all about shrinkage—and I assure you there's no shrinkage from temperature change.'

"That started me asking a chain of questions. He answered that his oil was delivered by a large inter-island barge. The barge picked it up from an ocean-going tanker that loaded in Tampico, Mexico.

"In his office I looked over the fuel records. It didn't take long for me to

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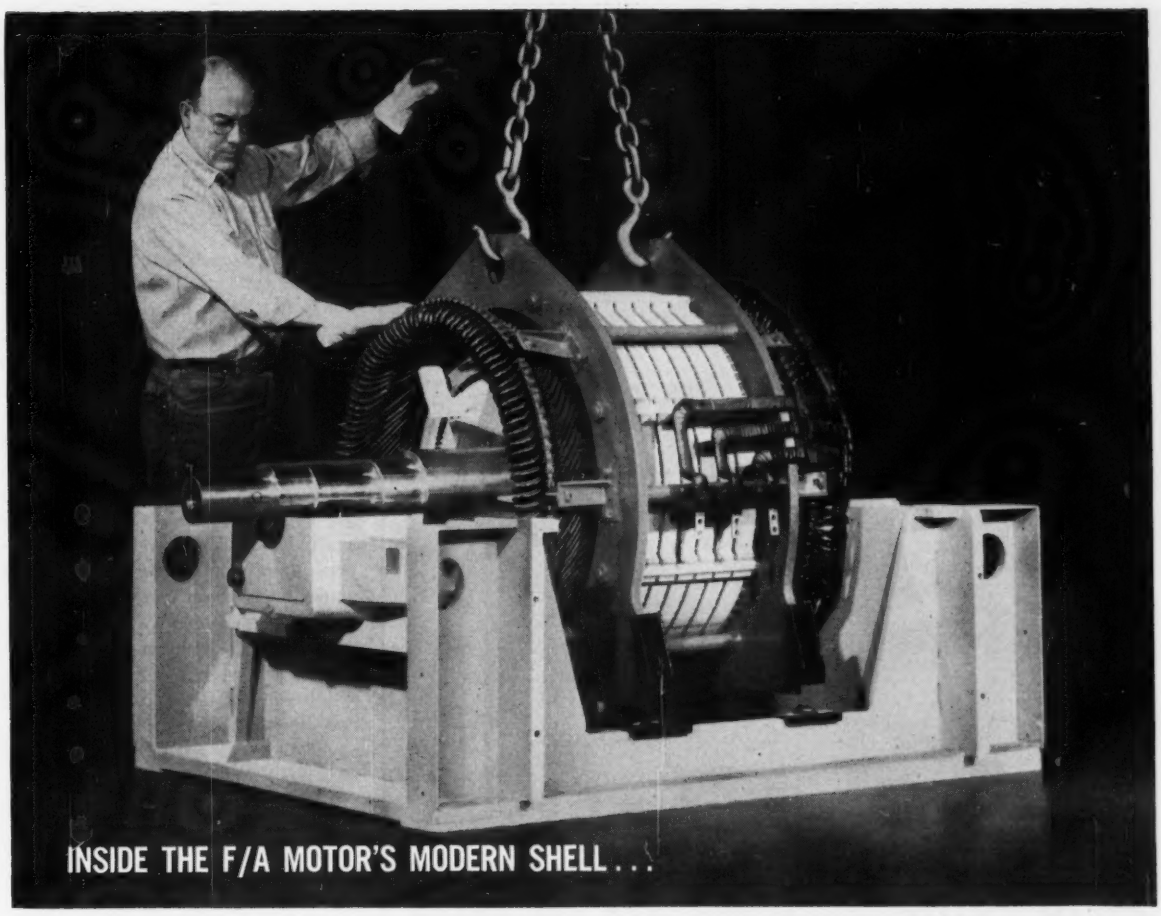

long life, lowest maintenance, backed by 7000 success stories

WEATHER-TESTED FOR OVER TWO YEARS...WITH NO MAINTENANCE!

This conventional indoor, 600-hp motor with Thermalastic insulation has been running outdoors for more than two years. Built before the F/A Motor was introduced, it has been subjected to these rigorous conditions:

- Twenty-four hours a day, five days a week, with weekend shutdowns to produce stopping and starting surges
- Summer and winter, all weather and temperature extremes
- Two-week shutdown during which it was sprayed almost continuously with fire hoses

It is still running smoothly and shows no signs of insulation breakdown or other deterioration.

In 7000 large-motor installations and over 15 million horsepower of Westinghouse large rotating apparatus, not a single breakdown occurred from Thermalastic® insulation failure.

One reason for this amazing service record lies in the unique molecular structure of Thermalastic insulation. Large, overlapping mica splittings are locked in a void-free, memory-type elastic bond, forming a perfect dielectric barrier which is maintained under *all* operating conditions.

Because of Thermalastic, your F/A Motor serves you longer and better. This insulation system withstands prolonged voltages, abrasion, corona arcing and frequent-starting surges. F/A Motor applications are virtually unlimited because Thermalastic is chemically stable, will not react, dissolve, crystallize or evaporate in contact with acids, alkalis, oils, lamp black, dirt, moisture or temperature extremes.

Consider what these proved performance extras can mean in down time and maintenance savings alone. For more specific test data, call your Westinghouse representative, or write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pa. J-15013

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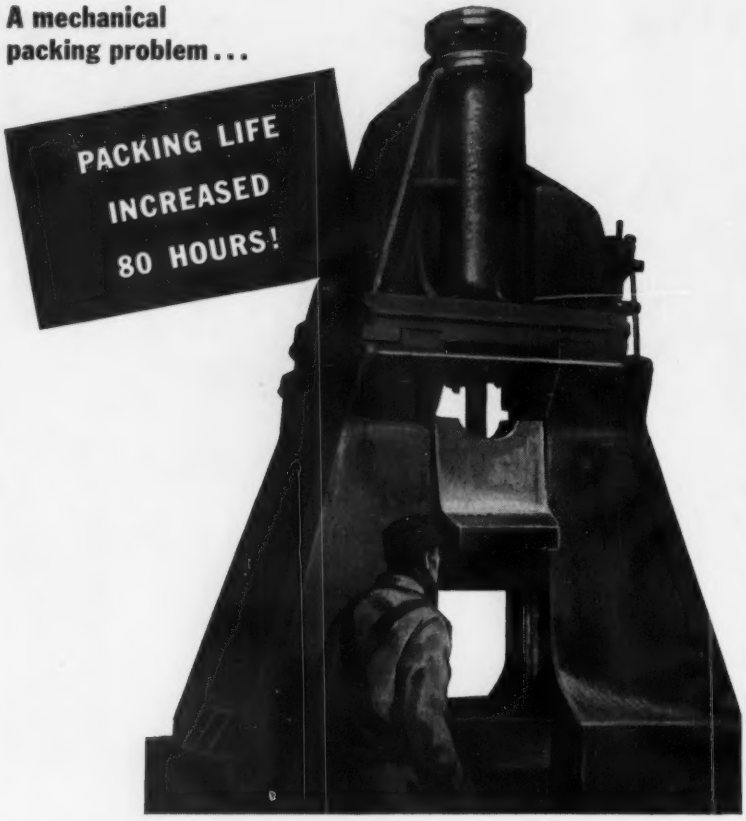
WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV MONDAYS

A mechanical packing problem . . .



HOW AN R/M DISTRIBUTOR KEPT A STEAM HAMMER FROM BLOWING ITS STACK

The packings on this 3500-lb.-capacity steam hammer formerly lasted about 160 hours. Then, one day, an R/M distributor advised using R/M Vee-Square,® a Big 7 Packing. It was a tremendous success! Packing life is now about 240 hours, very few adjustments are needed, and maintenance costs are way down.

Your local R/M distributor is thoroughly familiar with packing problems. He will be glad to be at your service. His own stocks, readily supplemented by any of the R/M warehouses strategically located all over the country, put R/M packings as near as your telephone. And R/M Big 7 Packing Types will do your job extremely well. Write for his name and address today.

THE BIG 7 PACKING TYPES

R/M's BIG 7 PACKING TYPES MEET 95% OF ALL PACKING NEEDS

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PACKING DIVISION, PASSAIC, N.J.
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Marmaduke

Continued from page 176

spot a few things that told me there was something rotten in the state of Santiago de Cuba, especially aboard the oil barge.

"After more checking I learned that the oil was pumped from the barge into the large main storage tanks. They held 40,000 barrels apiece. From there the oil was transferred into smaller tanks, for daily consumption. I did a little pencilwork and found that the daily consumption from those day tanks didn't jibe with the invoiced quantity as delivered to the large storage tanks. So my problem boiled down to finding what happened to all that delivered oil that was paid for, but vanished into thin air somewhere between the main storage tanks and the burners.

"I asked Orocovis what his payments were based on. He explained that the large storage tanks were gaged soon as the barge stopped pumping. The gaging was done by his assistant and the barge's chief engineer. Then the volume of the oil in the tanks was calculated and payment based on volume. I asked if he had a full storage tank that hadn't been used since it was filled about two weeks before. He checked and found that one of the four tanks hadn't been pumped out of.

"When one of his boys sounded that tank, I found that it had 7.3 inches of oil less than his sounding showed upon delivery. That put me onto the trail of one of the neatest oil swindles I've ever run into, on land or sea.

"'When do you expect your next oil delivery?,' I asked.

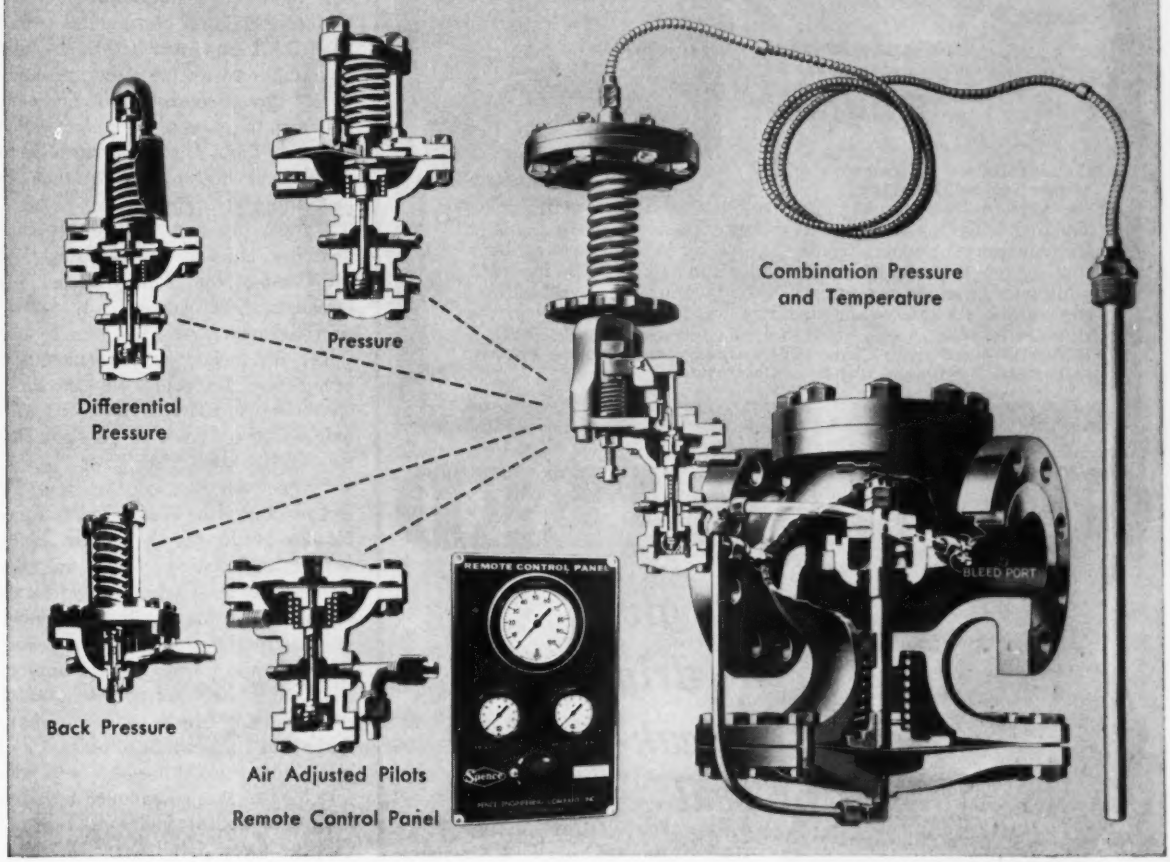
"'Tonight at 8 pm,' was his answer. I told Orocovis I'd be back at the plant then and that I'd probably bring Bill with me.

"Bill said he'd be happy to have supper with Carmelita and me when I called him at the distillery. During supper that evening Carmelita wised me up to something that helped a lot: She knew the chief of the oil barge. He was a slippery little character from Morocco, known only by the nickname of Ali Baba. And he had a reputation for making a fast buck. Carmelita said he had done everything in the islands from smuggling arms to smuggling dope. He had one weakness: rum.

continued

VALVE TIPS:

All Pilots Fit All Main Valve Sizes Downtime, Maintenance, Inventory Reduced



Let's start off by admitting there's no such thing as a "maintenance-free" regulating valve. Any valve that automatically controls temperatures or pressures within close limits can be affected by dirt in steam lines.

If trouble does develop, engineers want a regulator they can get back on the line — fast. That's one reason why more engineers are standardizing on Spence Regulating Valves with externally mounted pilots. The simple test of disconnecting the external bends establishes whether the trouble is in the main valve or the pilot.

If the main valve is the trouble spot, it can be maintained without removing the valve body from the line. If the pilot is the trouble spot, it is easily removed for cleaning. However, if production downtime is a strong factor, the fastest method is to install a spare pilot and it is inexpensive.

All Spence pilots fit all sizes of Spence main valves. If you have twenty pressure regulators, for instance, all you need is *one spare pilot*. It will fit all main valve sizes from ¼" to 12".

Another advantage of the Spence design is the external pilot is interchangeable. You can change the function of a regulator by merely changing the pilot. In many plants this can represent an important factor in reduced inventory costs because you only carry a few inexpensive extra pilots instead of complete regulators. Obviously, there is also a considerable savings in labor costs when a valve can be converted, in the line, from a temperature regulator to any one of various pressure regulators.

The pictures above show a few of Spence's wide line of automatic regulators. For more information write for Bulletin TE.

SPENCE ENGINEERING COMPANY, INC.
Walden, New York 58-148

For more facts circle 314 on Reader Service card, p 125

Robertshaw's Vibraswitch Malfunction Detector
prevents costly machinery damage by actuating an alarm or shutting down machinery the instant excessive vibration occurs. Vibraswitch anticipates trouble caused by failing bearings, bent shafts, broken blades or overspeeding and can easily be installed on pumps and motors, cooling tower fans, compressors and blowers, gas and diesel engines, and turbines. For further detail write for Bulletin RF-586. **Aeronautical and Instrument Division, Robertshaw-Fulton Controls Company, Santa Ana Freeway at Euclid Avenue, Anaheim, California**

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Marmaduke

Continued from page 178

"About halfway through our meal Carmelita tipped us off that the barge had tied up and started pumping oil. She could hear it from her upstairs-apartment window.

" 'Ali Baba always comes here for drinks after he gets the pumps going,' she informed us.

" 'Good,' I said, doing some fast brainwork. 'Here are two plans we can follow to handle this hombre. We'll call the first Plan A, the second Plan B.' I explained both plans, and the situation we'd use either on. Each of us agreed to carry out his part. Just then the slippery little chief sidled into the bar. He was brown as a pirate and his shifty eyes took in everything at a glance.

" 'Meet my good friend Mr Surfaceblow, chief of the *Quaimaro*, and Mr Pender from New Orleans. Mr Orocovis, here, you already know,' said Carmelita, showing him to our table. Ali looked at us suspiciously, but before he could say anything Carmelita shoved a bottle of Bacardi before him and filled up his glass. She was carrying out Plan A.

"When she assured him that I'd feel insulted if he even offered to pay for the bottle, he worked the kinks out of his hoisting elbow and went into high gear. That guy could throw drinks down his hatch with either boom, especially if the drinks were free. Bill and Carmelita kept him entertained so he'd get potted faster. I started giving him a snow job about a big deal I was about to pull off and hinted that I might need his help. Before long he was so rummed up from the liquor and so fogbound from us yapping away that he started swimming upstream. That's when I slipped out of the bar. Orocovis left with me. He'd had an SOS from the plant: something was wrong there.

"Aboard the oil barge I headed for the pump room, but stopped dead in my tracks. I heard a shrill hissing sound coming from the pump's direction. Soon as I got down into the small pump room the mystery of the vanishing oil was solved. The noise was made by a one-inch valve open to atmosphere in the pump's suction. It was cracked open only a few turns, but enough air rushed in to mix thoroughly with the agitated oil. That

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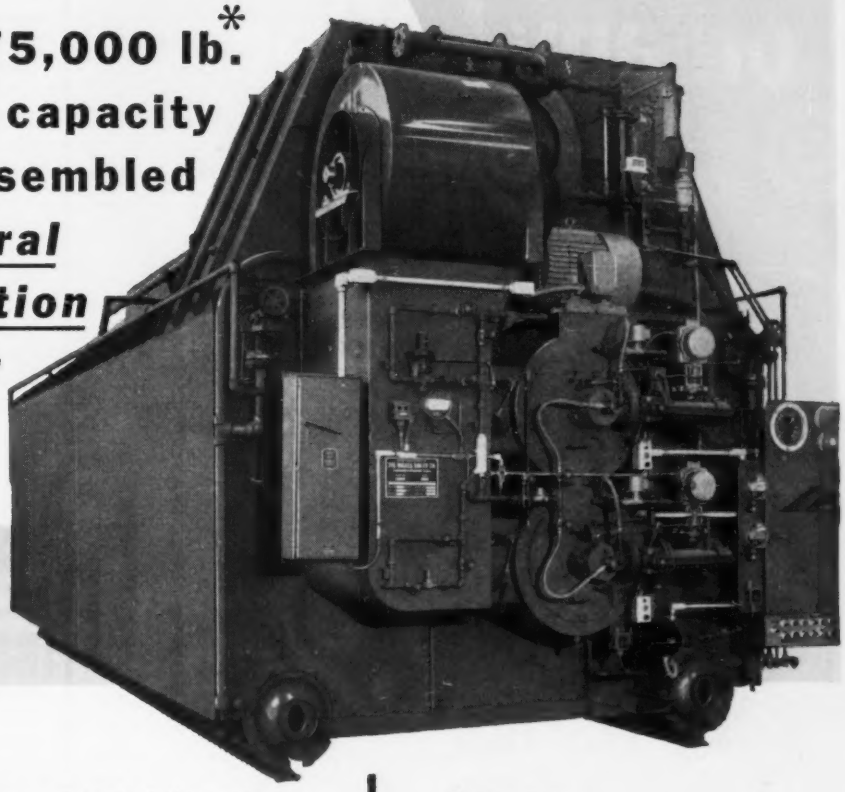
...now from WICKES

a new 75,000 lb.* per hour capacity shop-assembled *natural circulation* boiler



*75,000 lbs. per hour present capacity.
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Wickes Type A units are of simple design, ruggedly constructed and adaptable to a variety of operating conditions and may be Oil or Gas Fired.

All units are shipped completely shop-assembled including superheater fuel burning equipment, safety and combustion controls, forced draft fan and drive, soot blowers and feedwater regulator.

Save on

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For more detailed information on Wickes Type-A steam boilers, write for our catalog 56-1. Bulletin 55-1 covers the complete line of Wickes Products and Facilities.

WICKES type A

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169

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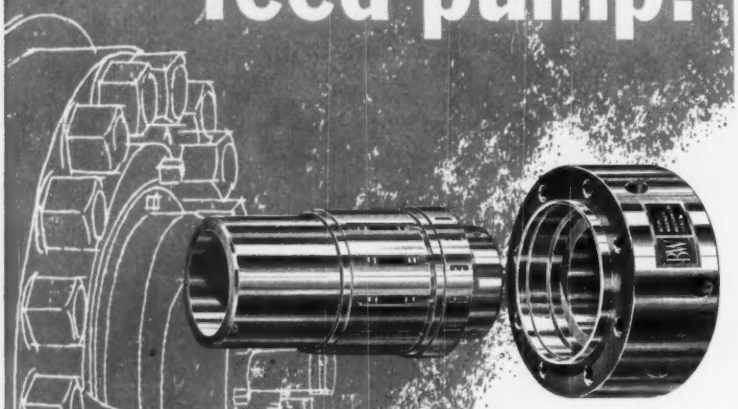
cut kw costs on any boiler feed pump!



Borg-Warner Mechanical Seals

Shaft leakage on a boiler feed pump means more than a little lost water. You can actually measure—in BTU's—the heat lost in expensive treated feed water.

"Type D" Borg-Warner Mechanical Seals are designed for the high temperatures and pressures of boiler feed service and cut this leakage to an absolute minimum. At the same time, they eliminate costly maintenance and down-time required with packing or inadequate sealing methods.

The end result is lower pump operating costs, and *lower cost per KW!*

NOW AVAILABLE—*a new 12 page bulletin describing the Borg-Warner Type "D" Seals. Operation, construction, installation and other useful information is included—write for your copy today!*

Borg-Warner® Mechanical Seals

P.O. Box 2017, Terminal Annex, Los Angeles 54, Calif.

Marmaduke

Continued from page 180

caused the oil to expand in volume. I reasoned that the tiny air bubbles would keep the oil expanded for several days, or at least long enough for the storage tanks to be gaged by the plant's chief accompanied by the barge's chief at each delivery.

"According to the full tank I had checked that morning, there was about 3% shrinkage. So Ali Baba had been selling all that air to the utility plant for good hard cash for the past two years. Then he sold his swindled oil to cash customers in other ports, lining his own pockets from the sale.

"I closed the air valve and got out of the pump room. Returning to the bar I winked at Bill to let him know I had found the trouble. By then Ali Baba was so well oiled himself that he could hardly navigate. So Bill and I carried the tanked-up chief to his bunk aboard the barge.

"Soon as he was safely stowed away in his bunk I went down to the pump room again. Bill kept an eye on the chief while I pumped about 5000 extra barrels of oil into the storage tanks ashore. That was Plan B. Ali Baba's records were properly signed and in order, but he didn't remember how the next morning.

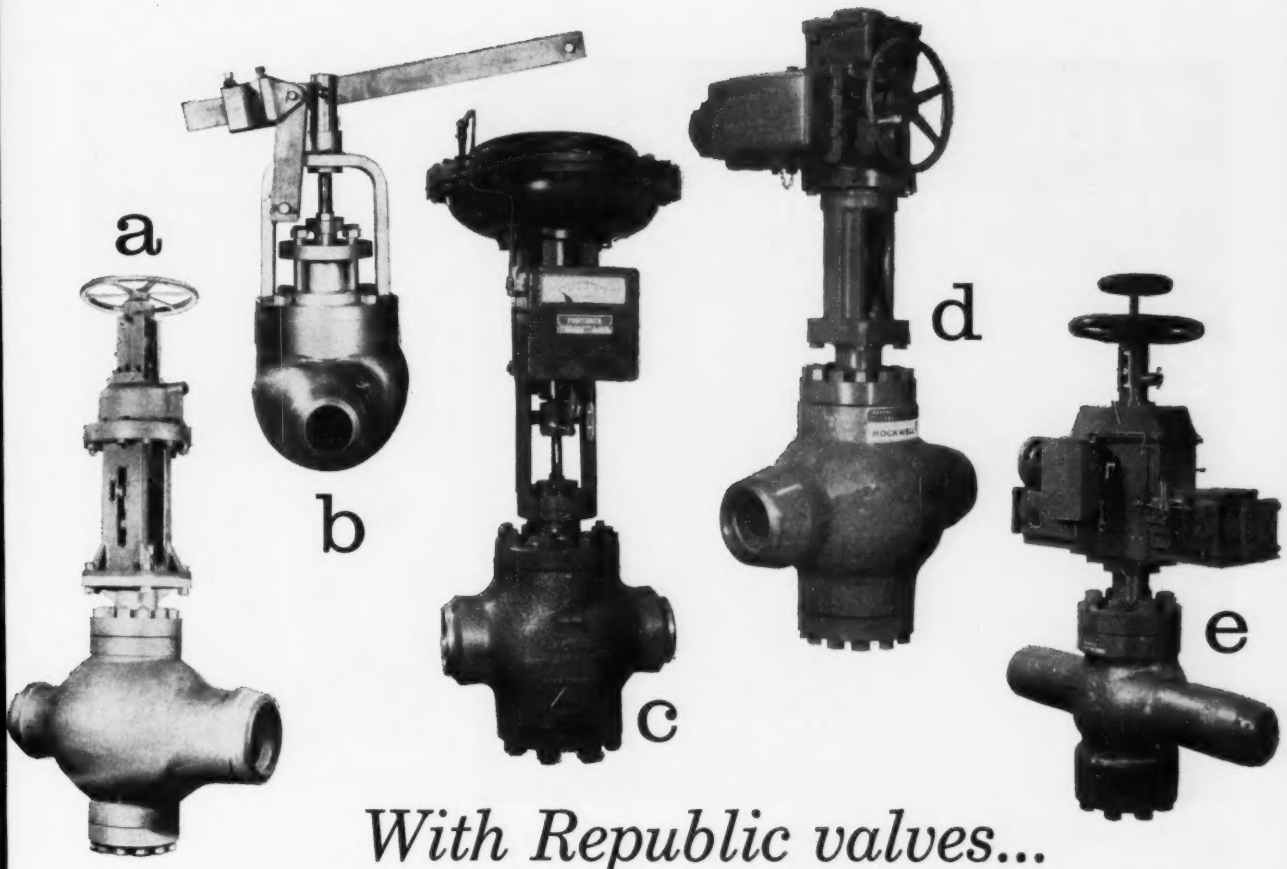
"The barge shoved off at high tide at 4 am, and next noon I explained what had happened to Orocovis. I suggested that he figure out all the oil he had been gypped out of in the past two years and deduct it from his next bill. He agreed. To show his appreciation he handed me a check for one thousand pesos.

"That was easy money," roared Marmy, turning back to the bar. "And all I had to do to earn it was pump two dollars' worth of rum into the barge chief's tanks while he was pumping air into the power company's tanks."—SME

Marmy's Mailbox

AGREES

"Marmy's Big Bust," Feb 1958, was rich. I've served on all kinds of ships so I appreciate his problem. I've seen liquor hidden in the l-p steam chest, condenser water chests, dead evaporators, ship's powder maga-



With Republic valves...

You get longer life, less maintenance

For over 35 years Republic valve developments have paced the changing demands for more sturdy valves by the most progressive utilities and industries. For such services as pump recirculation control, feedwater regulation, steam pressure reducing and high pressure water control, Republic valves have established a reputation for durability, long life and trouble-free performance.

Superior valve design—Republic research into the causes of valve noise and vibration, and also the wear resisting and galling properties of materials has resulted in a modern line of Republic valves of advanced design. Republic valve contours are designed to produce not only the desired regulating characteristics but also to reduce erosion damage and noise as well. Extra large guide bushings, extra deep stuffing boxes, solid plug inner valve construction, plus precise manufacture and long-life materials make Republic regulating valves perform better, last longer, with less maintenance.

Wide selection of valves and features—Rockwell-built Republic regulating valves shown on this page are representative of the complete Republic line:

a. **Cylinder operated valve**
b. **Lever operated valve**
c. **Diaphragm operated valve**
d. **Motor operated valve**
e. **Toggle head operated valve**
f. **Diaphragm operated angle valve**

And, for many special applications, such Republic accessories as pneumatic and electric valve positioners for hysteresis-free control, and a complete line of controllers are available.

Whatever your regulating valve problem, let Republic engineers put their years of application experience to work for you. For additional information, see your Republic representative, or write to Republic Flow Meters Company, 2240 Diversey Parkway, Chicago 47, Illinois.

REPUBLIC INSTRUMENTS AND CONTROLS
more fine products by
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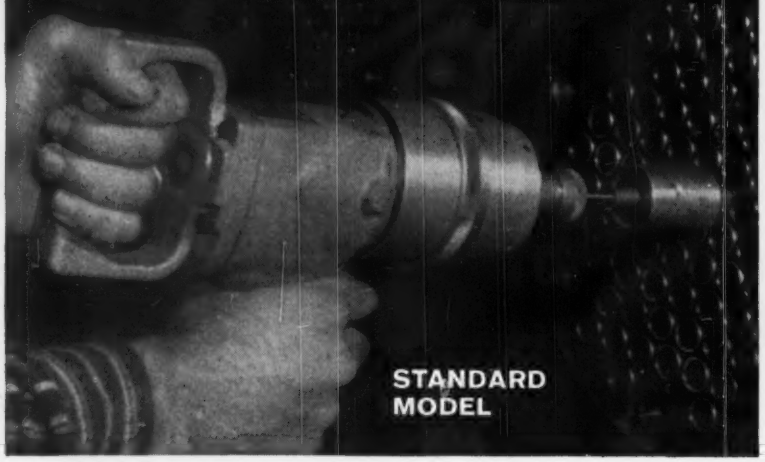
ELLIOTT air magnetic tube expander drives

automatically controlled for fast, accurate tube rolling



Designed for faster, precision tube rolling, the standard model Elliott Air-Magnetic drive is setting new records for speed and accuracy. Some operators average 12 tubes per minute. Desired torque easily preset by rotating forward end of unit. No tools needed. Rolling stops when preset torque levels are reached. Includes trigger-controlled, explosion-proof air motor in single unit. Magnetic control, no springs. Balanced for easy handling. For tubes ¼ in. through 3 in. *Standard model* handles most jobs. *Heavy-duty* for higher torque.

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Other related accessories include Elliott tube gage, tube plugs, tube pilot, and tube rolling lubricant.

Write for descriptive literature *today*.

Y9-3

ELLIOTT Company
LAGONDA PLANT, Springfield, Ohio

Marmaduke

Continued from page 182

zines, under bulkhead sheathing, in gun barrels and even in the stationary generator windings.

H M NEUHAUS, *China Lake, Calif.*

BETTER HIDING PLACE

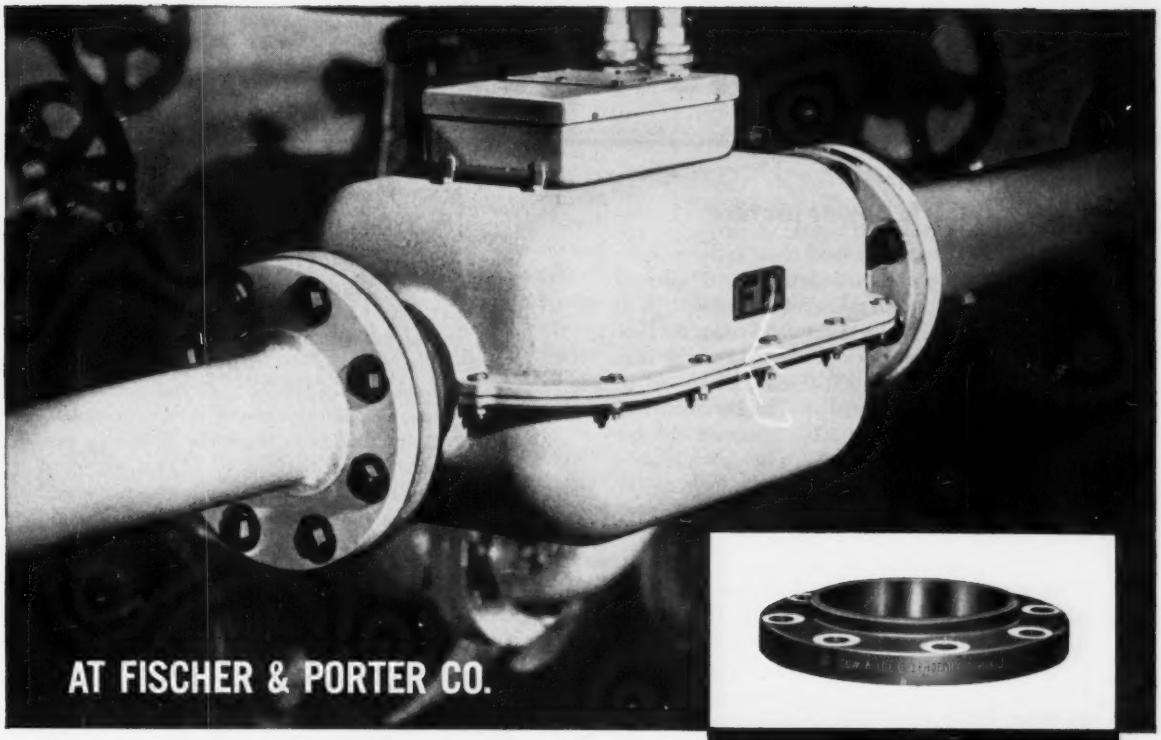
When POWER arrives, all work stops in our plant until we read Marmy's latest escapade. I wonder why he hid his 20 cases of tiger sweat inside the main engine l-p cylinder ("Marmy's Big Bust," Feb 1958). During prohibition I kept my stuff in a Lysol bottle in my cabin. Another time I cut the head out of a 50-gal drum, left it out on deck and stuck half a dozen new mops in it. The 40 thieves (Custom Dept inspectors) passed it up.

I was the only guy on the San Francisco Embarcadero who always carried a spare motor armature in his sea bag. Hollowed out and covered with a canvas bag, neatly tied together and mounted on the bulkhead in the engine room, it cured many hangovers for me.

If Marmy had thought of it, he could have had a wooden armature for the generators, also the 50-gal foam extinguisher makes a good place for Scotch. A little soda and acid kills the iodine taste of Scotch and makes it more palatable. Of course, we Monday quarterbacks always have lots of time to think. But still, the old boy should have been able to get his chemicals into port.

S KRONE, *Jamestown, N. D.*

MARMY'S NOTE: *Bilgewater on hiding a couple of bottles. I had 20 cases.*



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For more facts circle 321 on Reader Service card, p 125

Powerscope . . . A selective look at

Tomorrow's electric power picture

Country's 200 investor-owned electric power companies plan to more than double their sales of electric power during the next ten years. E O George, Detroit Edison VP, states that in 1958 residential and rural sales of electric current were 160 billion kwhr. By 1968 this figure should be about 415 billion, he predicts. In the industrial field he believes that the 1958 figure of 285 billion kwhr will be around 620 billion, while sales of commercial electric power will climb from 100 billion kwhr sold in 1958 to upwards of 225 billion by 1968.

Total power generation in U.S. last year was 737 billion kwhr, but by 1968 this could reach 1.5 trillion kwhr, according to Gwilym A Price, board chairman of Westinghouse Electric Corp. To deliver apparatus needed to meet these demands, Westinghouse cites the following developments: A longer turbine motor blade that will permit construction of a superpressure cross-compound turbine of 800,000-kw capacity; switchgear using a gas as the medium to interrupt and extinguish electric arcs; extra h-v transmission which will enable nation's 350 electric utilities to tie into one national power grid; advancements in atomic power.

On the latter point, Westinghouse says it's ready to design, develop and build a 330,000-kw nuclear power plant. Such a plant could be operating within five years and could produce power at costs competitive with fossil fuels in high fuel cost areas of the country.

Within the foreseeable future thermoelectric generators will convert heat directly into electricity with an efficiency as high as 35%. In making this forecast, Westinghouseman Dr Clarence Zener said that this top efficiency would come from careful selection of materials that give maximum thermoelectric performance within temperature bands where they operate best.

Already Westinghouse and Carrier Corp have Navy contracts to design, construct, test and furnish 5-kw thermoelectric units. Generators will convert heat of a burning fuel, probably diesel oil, directly into electricity. Carrier says fabrication will begin immediately, aiming at full operation within a year.

A fascinating possibility: Some day power companies may pay you instead of sending out a monthly bill. Dr L J Giacoletto, Ford Motor Co's scientific lab, in saying that possibility of solar energy is not new, added that up to now there has been no feasible plan to store this power. He offers this solution: Instead of trying to store sun-generated power for individual use, turn excess electricity back into the power line for daytime industrial use and receive credit for it. "Meters that measure electricity drawn by a home already work both ways," he pointed out. "Electricity generated simply would reverse a meter's action, subtracting from the kwhr of energy previously used." Calculations show that a typical Milwaukee-Chicago-Detroit area homeowner would generate three times more energy than he would use. "This," says Dr Giacoletto, "represents a potential net return over the year of about $200.

Other eye-catching developments

A record-breaking 200,000-sq-ft condenser, largest in the world, recently went into commercial operation with Unit No. 19 at the Fisk generating station of Commonwealth Edison Co. It serves the new 327-mw turbine-generator at this station which furnishes power to Chicago. Allis-Chalmers manufactured both units.

Total demand for lubricating oils and greases made in U.S. will increase 5% this year over 1958 to a level of 151,000 barrels per day, forecasts Thomas W Phelps, manager of economics department of the Socony Mobil Oil Company, Inc.

In relaying, two major disclosures: (1) Allis-Chalmers has developed an all-transistorized overcurrent relay for ac switchgear applications. It has no moving parts, mounts in one-third space of conventional induction relays. (2) General Electric's new static protective relay has transistorized design, operates within 1½ cycles. It has completed exhaustive field tests on Muskingum-Philo 138-kv line of The Ohio Power Company.

A look at engineering education

Graduating engineering students at U of Michigan have received 1.7 job offers each. This is up slightly from last year's average. Too, a sampling of job offers indicates salaries are up about 5%.

Three new brochures to guide young engineers during their first few years after graduation have been prepared by Engineers' Council for Professional Development.

"*Your First Five Years*," the first brochure, outlines the challenge to the young graduate, cites several guiding principles,

this month's power-field happenings

ART SOMMER, Assistant Editor

suggests a 6-point professional development program (price, 10 cents). "*Selected Reading for Young Engineers*," is the second item, sells for 15 cents. Third publication, "*Personal Appraisal*," aids the young engineer in evaluating his progress so he may effectively plan his steps in future professional development (price, 10 cents). Write ECPD, 29 W 39th St, New York 18, N. Y.

Average professional income of engineering teachers in U.S. has risen 8.3% since 1956, and their basic teaching salaries have increased 13.5% over the 2-yr period, according to a survey published for Engineers Joint Council. The survey covered more than 5000 engineering teachers in the U.S.

Engineering education in Soviet Russia is of good quality, but it's not for us. Ralph Fadum, head of dept of civil engineering, N. C. State College, speaking at the recent ASCE convention in Cleveland, said that specialization in Russian engineering education is at such a high level that the curricula are designed to prepare students to be immediately useful to industry with a minimum of additional training. The Russian student is not prepared to take advantage of a wide variety of opportunities. "On the contrary," he added, "it is the purpose of the Russian system to discourage a shift of employment from one specialty field to another." This results in dividing engineering education into some 150 different specialties, contrasting sharply with the less than 20 fields that are currently accredited in the U.S. Mr Fadum was a member of an engineering education mission to Russia in 1958.

Freshman engineering enrollment has declined markedly for the first time in eight years. Too, one out of five engineering schools expect a further drop in freshman enrollment next fall. These were findings of a joint EJC and ASEE study covering 223 U.S. institutions granting engineering degrees. In 1958, 70,029 engineering freshmen enrolled, compared with 78,757 in 1957.

The power scene abroad

Moscow News reports Soviet designers have completed preliminary drawing for what will be the world's biggest gas turbine—a 100,000-kw unit, about doubling kw of any existing gas turbine.

Paris—McGraw-Hill World News. Commercial production of nuclear power in continental western Europe began recently when a reactor at Marcoule began feeding electricity into French network.

Contract for new semioutdoor power plant to be built in Bangkok as a major step in Thailand's electrification and industrialization program has been awarded to The Kuljian Corporation.

U.S. Steel men learn ABC's of lubrication in mobile classroom

U.S. Steel Corp has put a traveling classroom into service to give its employees theoretical knowledge and practical job know-how in the proper maintenance of plant lubricating equipment. The classroom is a 35-ft mobile training unit, equipped with all components of a centralized lubricating system, photo, left. These can be plugged into a built-in lube reservoir for "live" demonstrations with actual lubricating materials. Work benches are at each end of demonstration area which seats fifteen persons for classes.

The mobile unit carries its own generator, can operate independent of outside power. It is completely air conditioned and has a heating system for use during inclement weather.

PRESSURES:
2000 psi
TEMPERATURE
1200°F.

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Style 177AI

Here is the tough, dependable packing you've been looking for. Style 177AI is built to take punishment . . . to easily withstand pressures as high as 2000 psi . . . remain resilient at temperatures to 1200°F. It's a packing that will give you the kind of service you've always wanted in high temperature valves, soot blowers, gauge glass fittings and similar applications.

Style 177AI is dry graphite lubricated to reduce friction to a minimum. Each strand of the closely braided asbestos yarn top jacket is reinforced with Inconel wire. Core consists of long fibre asbestos and flake graphite.

Available in Spools or in Die-Formed Rings. Rings available with either square cross section or with special bevels for concave-convex nest sets.

Get full information on Style 177AI Packing now. Request catalog describing the full line of "John Crane" Packings.

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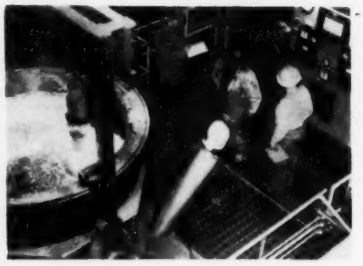
CRANE PACKING COMPANY

Reports from the field

Turner Construction named to build Engineering Center

Turner Construction Company of New York has been named as the general contractor for the United Engineering Center. New headquarters for some of the nation's leading engineering societies will be erected on the west side of United Nations Plaza between 47th and 48th Streets in New York City.

The center will be an 18-story $10,000,000 tower structure. Its 260,000 sq ft of floor space will house ten engineering societies, representing 250,000 members, as well as an engineering societies' library. Space will be set aside for educational exhibits.



Low-hydrogen steel forgings produced by stream degasser

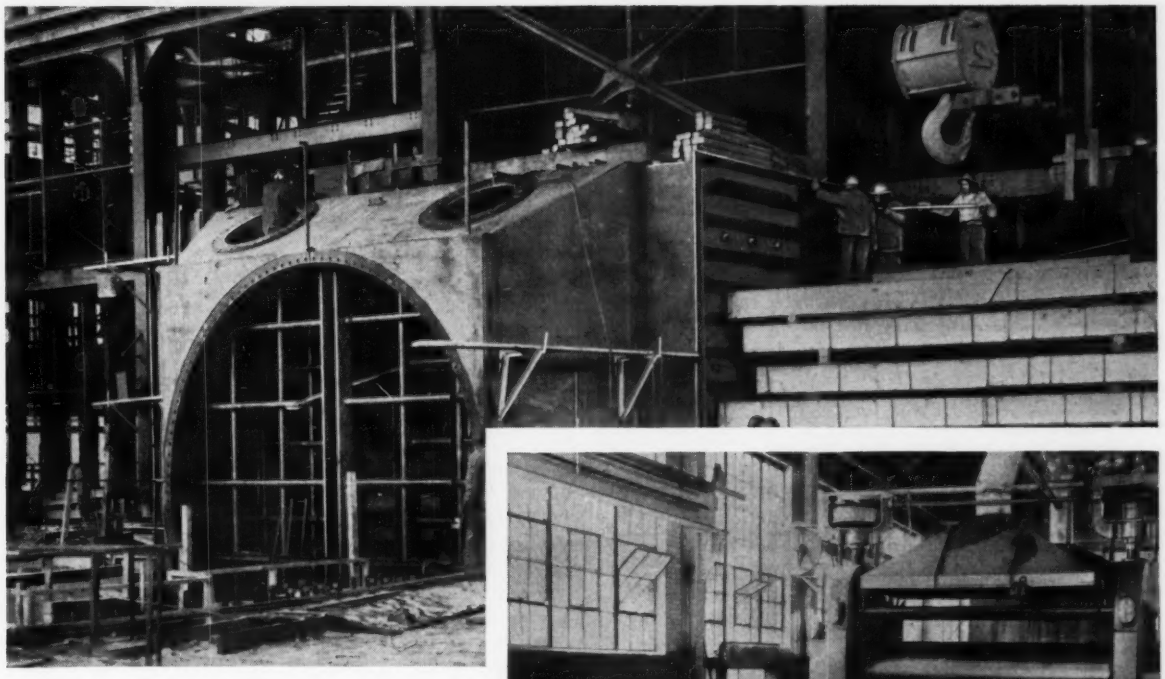
For high-speed high-stress applications in rotating machinery, steel must have low hydrogen content. Excess hydrogen can cause flaking, microcracks and embrittlement, which in turn lead to failure under stress.

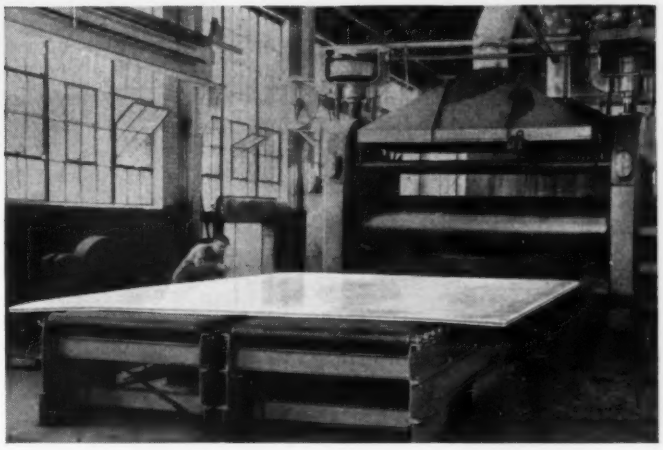
This half-million-dollar vacuum stream degassing facility is one effort to cut down hydrogen content. Installed by Baldwin-Lima-Hamilton Corporation's Standard Steel Works Div, equipment has a 15-ton capacity. It can handle total output of the division's electric furnace.

Molten steel was vacuum treated experimentally as far back as the 1880's, and large ingots were cast in a vacuum in 1914, but costs were high, quantity small and applications limited. Expanded use of high-speed rotating machinery in the past ten years has boosted demand for vacuum-processed steel, and led to new methods and facilities. In the vacuum stream degassing process, molten metal is exposed to a high vacuum

For more facts circle 322 on Reader Service card, p 125

7-TON COPPER-ALLOY PLATES FOR LARGE SURFACE CONDENSERS





TOP: View of the new Clinch River Plant of Appalachian Power Co., at Carbo, Va. **ABOVE:** Tubing one of the two huge Allis-Chalmers surface condensers. The 26' x 15' openings in the shell use two Anaconda Leaded Muntz Metal-274 plates, each 156" x 189" x 1½" and weighing 13,700 lb. American Brass furnished the eight plates required, as well as the Arsenical Admiralty-439 tubes for the unit above — 19,100 lengths, ⅞" x .049" x 30'. **RIGHT:** The big rolling mill at American Brass Company's Detroit Division which produced the plates.

THE unusually large plates required for the tube sheets at Clinch River Plant are standard items of The American Brass Company, which produces plates of copper and a number of copper alloys in rectangular sizes up to 156 inches in width and 15,000 pounds in weight. The maximum standard limits for circles are 160 inches in diameter and 11,000 pounds in weight. Half circles can be produced up to 13,000 pounds in weight.

ROLLED PLATES SUPERIOR. Anaconda rolled plates are commercially flat, accurate in dimensions, and free from surface imperfections and porosity often prevalent in cast plates.

SPECIAL JOBS. Whenever you have a problem involving extremely large plates in standard or special copper alloys, The American Brass Company will gladly assist in its solution. For general information on Anaconda Condenser Tubes and Plates write for Anaconda Publication B-2: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

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MADE BY THE AMERICAN BRASS COMPANY

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Adjustable
SPROCKET RIM
with Chain Guide

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Snapit-On

Protector Shields for CONDENSER AND BOILER TUBES

DETERS EROSION

PREVENTS MATERIAL WASTAGE

REDUCES MAINTENANCE

GIVES TUBES LONGER LIFE

MADE IN STAINLESS STEEL
AVAILABLE IN ALL SIZES

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circle 325 on Reader Service card, p 125

Reports from the field

Begins on page 188

as it is poured in a continuous stream from ladle to an ingot mold. Torn apart by the vacuum, stream bursts into a spray exposing enormous surface area. The vacuum picks up a high percentage of entrapped gases. Foreman, p 188, can check process through a viewing window.

Yucca power plant goes on the line

First power from the 80,000-kw Yucca power plant at Yuma, Ariz. was produced on March 5th, marking completion of the $24-million installation.

This unit, which took 18 months to build, is owned by California Electric Power Co. Arizona Public Service will own an identical steam-electric unit to be built later. Imperial Irrigation District has agreed to purchase part of Yucca's power.

Calendar of Events

June 10-12—Instrument Society of America, 2nd International Symposium on Gas Chromatography. East Lansing, Mich. Details from H S Kindler, ISA, 313 Sixth Ave, Pittsburgh 22, Pa.

June 11-12—Southern Research Institute, conference on "The Undiscovered Earth." Dinkler-Tutwiler Hotel, Birmingham. Details from SRI, 2000 Ninth Ave South, Birmingham 5, Ala.

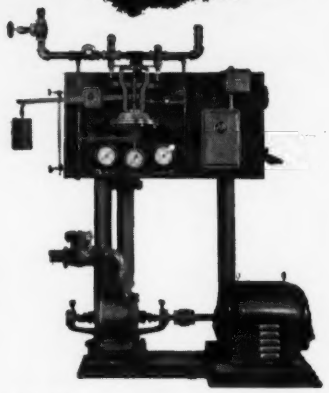
June 14-18 — American Society of Mechanical Engineers, Semi-annual meeting. Chase-Park Plaza Hotels, St. Louis, Mo. Details: ASME Meetings Dept, 29 W 39th St, New York 18, N. Y.

June 15-19—New York University, College of Engineering, course on thermoelectric materials. Details from Dr J P Nielsen, NYU College of Engineering, New York City, N. Y.

June 17-20—National Society of Professional Engineers and **New York State Chapter,** Engineering

Cut Steam Costs

with Stickle's differential drainage and boiler return system



A closed pumping system for returning condensation from heating and processing equipment under pressure directly to boiler at temperatures only 15 to 20 degrees lower than those at operating pressure. For plants using steam pressures between 50 and 250 lbs. Cuts the cost of steam these eight ways:

1. Cuts fuel costs 10% to 25% by completely salvaging condensate and returning to boiler at 300 degrees or higher.
2. Raises production with higher, more uniform boiler pressure, higher temperature steam.
3. Reduces use of raw make-up water 85% to 90%.
4. Cuts maintenance on boilers, steam lines, traps and valves.
5. Improves quality by permitting operation of processing units at peak efficiency.
6. Cuts power used for pumping up to 75%, since system requires only 25 lbs.
7. Automatically maintains positive circulation without steam loss.
8. Eliminates flash steam waste.

FREE BULLETIN!
Write or wire for details and free Bulletin 250.

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2265 Valley Ave. • Indianapolis 18, Ind.
SINCE 1905

Stickle Equipment
Cuts the cost of steam

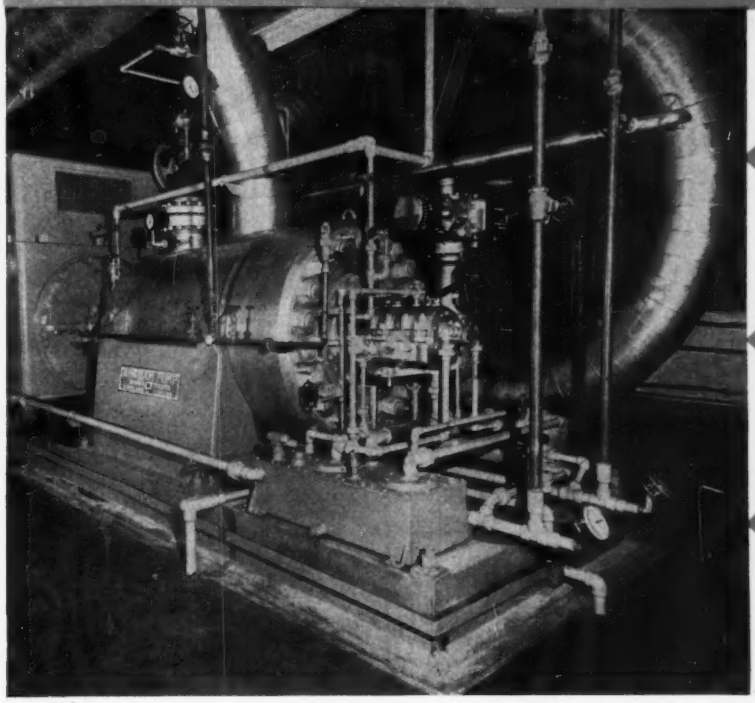
Steam Traps • Feed Water Heaters
Regulating and Reducing Valves
Drainage and Boiler Return Systems

circle 326 on Reader Service card, p 125

Bingham

'DOUBLE VOLUTE' BARREL TYPE BOILER FEED PUMPS

THE ULTIMATE IN DEPENDABILITY FOR HIGH PRESSURE SERVICE



BINGHAM BARREL TYPE HIGH PRESSURE BOILER FEED PUMPS

PACIFIC POWER AND LIGHT COMPANY
Glenrock, Wyoming

ENGINEERS AND BUILDERS
Ebasco Services, Inc.

Bingham Barrel Type Boiler Feed Pumps, installed in the Pacific Power & Light Company plant at Glenrock, Wyoming. Each pump is designed to deliver 1875 GPM at 2300 PSI, operating at 3560 RPM.

Bingham "Double Volute" Barrel Type Boiler Feed Pumps are furnished with forged outer barrel for high pressure service. Pumps of this type are available for a wide range of capacities and heads. Your nearest *Bingham* office will be glad to give you full details on request.

BINGHAM BARREL TYPE BOILER FEED PUMPS feature:

- "Double Volute" construction.
- Double suction first stage for low NPSH.
- Balanced axial thrust (no balancing drums needed).
- Kingsbury Thrust Bearings.
- Stuffingboxes are arranged for either packing or mechanical seals.
- Stuffingboxes are subjected to suction pressure only.
- Designed for high operating speeds.

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DOUBLE VOLUTE PUMPS RADIAL BALANCE

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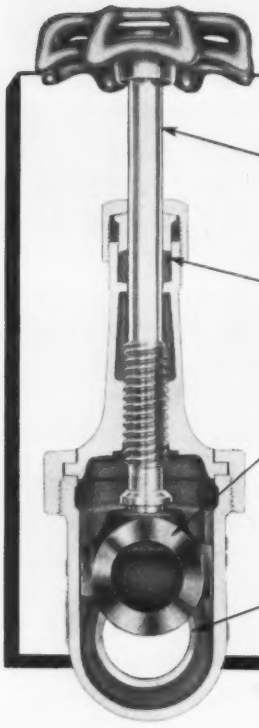
Outstanding Valve performance with

KENNEDIZED DISCS

an entirely new development in bronze gate valve construction that extends service life beyond comparison . . .



PROVEN BY USE!

KENALLOY STEM . . .

Exclusive KENNEDY alloy that prevents dezincification and corrosion and provides smooth, non-galling threads and bearing surfaces. In a rugged use test, this stem withstood a mechanical loading of 18 foot-pounds closing torque and after 25,000 cycles was like new!

PACKING . . .

New type packing made of molded graphite asbestos with a Buna "N" binder required no replacement during or after 25,000 cycles.

KENNEDIZED DISC . . .

In punishing use tests, the super mirror finish of the KENNEDIZED disc actually improved with wear! Disc showed no galling or other wear marks after 25,000 cycles at 150 lbs. saturated steam pressure. This remarkable wear resistance is combined with an extremely low coefficient of friction, smooth sliding properties, excellent anti-seizure characteristics and corrosion and galling resistance. Tests and in-use results prove these discs set a new and unmatched high standard in valve performance.

SEAT . . .

Due to the low coefficient of friction and smooth sliding properties, the action of the KENNEDIZED disc actually improved the finish on the seat. Here, again, no galling was found on the seat after 25,000 cycles.

For the complete KENNEDIZED DISC story, write for Bulletin 574.

Fig. 525KD
125-Pound S.W.P.
Bronze Gate Valve.

KENNEDIZED DISCS
NOW AVAILABLE IN THESE KENNEDY VALVES . . .

FIG. 427KD
125-Pound S.W.P. Bronze Gate Valve— Non-Rising Stem, Inside Screw, KENNEDIZED Wedge Disc.
WORKING PRESSURES: Saturated Steam, 125 lbs.; W.O.G., Non-Shock, 200 lbs.

Fig. 525KD
125-Pound S.W.P. Bronze Gate Valve— Union Bonnet, Rising Stem, Inside Screw; KENNEDIZED Wedge Disc.
WORKING PRESSURES: Saturated Steam, 125 lbs., W.O.G., Non-Shock, 200 lbs.

Fig. 78KD
200-Pound S.W.P. 550° F. Bronze Gate Valve— Union Bonnet: ¼"-2"; Bolted Bonnet: 2½"-3"; Rising Stem, Inside Screw; KENNEDIZED Wedge Disc.
WORKING PRESSURES: Steam at 550° F., 200 lbs.; W.O.G., Non-Shock, 400 lbs.

Fig. 518KD
300-Pound S.W.P. 550° F. Bronze Gate Valve— Union Bonnet: ¼"-2"; Bolted Bonnet: 2½"-3"; Rising Stem, Inside Screw; KENNEDIZED Wedge Disc.
WORKING PRESSURES: Steam at 550° F., 300 lbs.; W.O.G., Non-Shock, 600 lbs.

KENNEDY VALVE MFG. CO.
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DUCTILE IRON VALVES • CAST IRON VALVES • BRONZE VALVES • INDICATOR POSTS • FIRE HYDRANTS

Reports from the field

Begins on page 188

Progress Exposition. Hotel Commodore, New York City. Details from NSPE, 2029 K St, NW, Washington, D.C.

June 18-20—American Society of Mechanical Engineers, Applied Mechanics Div, Conference. Virginia Polytechnic Institute, Blacksburg, Va. Details from ASME Meetings Dept, 29 W 39th St, New York 18, N. Y.

June 21-26 — American Society for Testing Materials, Annual Meeting. Chalfonte-Haddon Hall Hotels, Atlantic City, N. J. Details from ASTM, 1916 Race St, Philadelphia 3, Pa.

June 22-26—Air Pollution Control Association, Annual Meeting. Hotel Statler, Los Angeles, Calif. Details from APCA, 4400 Fifth Ave., Pittsburgh 13, Pa.

June 24-26—Instrument Society of America, 2nd Nuclear Instrumentation Symposium. Idaho Falls, Idaho. Details from H S Kindler, ISA, 313 Sixth Ave, Pittsburgh, Pa.

June 29-July 3—New York University, College of Engineering, course on ductile iron. Details from Dr J P Nielsen, NYU College of Engineering, New York City, N. Y.

July 26-Aug 7—Columbia University, Dept of Industrial and Management Engineering, Eighth Utility Management Workshop. Arden House, Harriman, New York. Details from Mrs Rae Wygant, 409 Engineering Bldg, Columbia U, N. Y.

Aug 9-12—American Society of Mechanical Engineers and **American Institute of Consulting Engineers,** Heat-transfer Conference. University of Connecticut, Storrs, Conn. Details from ASME Meetings Dept, 29 W 39th St, New York 18, N. Y.

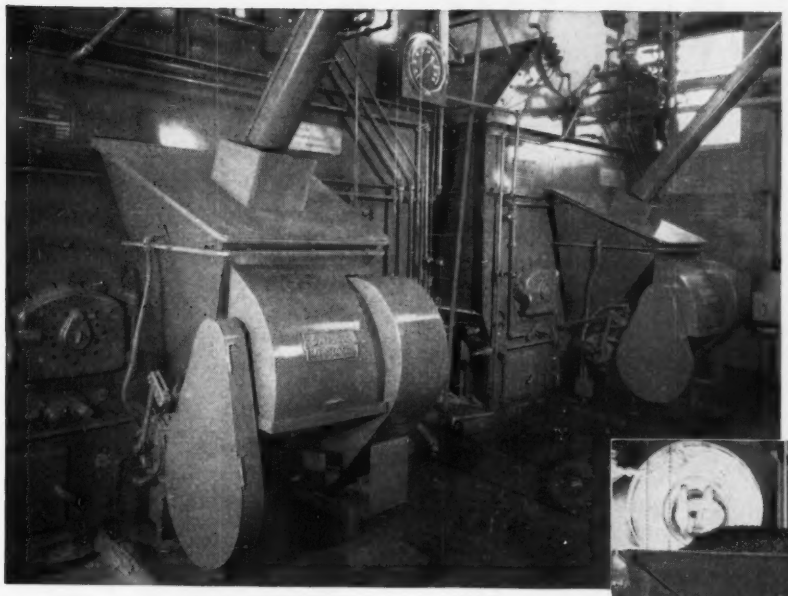
August 27—Illinois State Chamber of Commerce, Water Resources Committee: Water Supply Conference. Abraham Lincoln and St. Nicholas Hotels, Springfield. Details: Illinois State Chamber of Commerce, 20 N Wacker Drive, Chicago 6, Ill.

continued

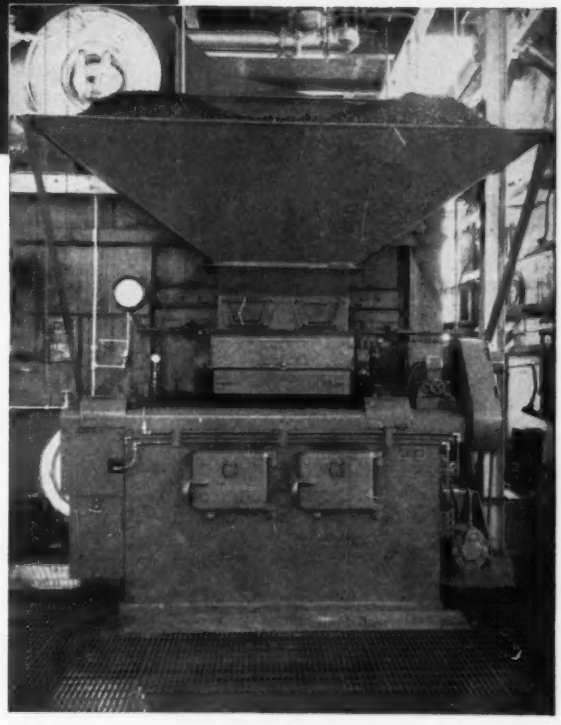
Does Your Package* Include

DETROIT STOKER ECONOMY?

*Package Boilers, of Course



Detroit LoStokers firing two Wickes Package Boilers, Type A.O. continuous rating—6000 pounds steam per hour.



As the installation convenience of the package boiler is more and more widely appreciated, the question often is asked "Why can't we have the advantages of a package boiler with the economy of efficient coal firing?"

The answer is—you can. Water tube package boilers designed for stoker firing are readily available.

And a *Detroit* Stoker gets the most economy out of coal, the most economical fuel. This economy plus the exceptional dependability and low maintenance of Detroit Stokers assures you steam at the lowest cost.

The Detroit Stoker line includes a number of types specially adapted to package boilers.

DETROIT STOKERS COST LESS . . . COST EQUALS INITIAL INVESTMENT PLUS UPKEEP PLUS PRODUCTION LOSSES DUE TO EQUIPMENT OUTAGE. THE TOTAL IS LESS WITH DETROIT.

Ask for details on Detroit Stokers with package or other boilers.

Detroit RotoStoker "CC"—continuous cleaning, Firing Springfield high pressure Package Boiler. Continuous rating—35000 pounds steam per hour. One of five furnished one customer.

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REVOLUTIONARY NEW SEAL

MAGNETIC
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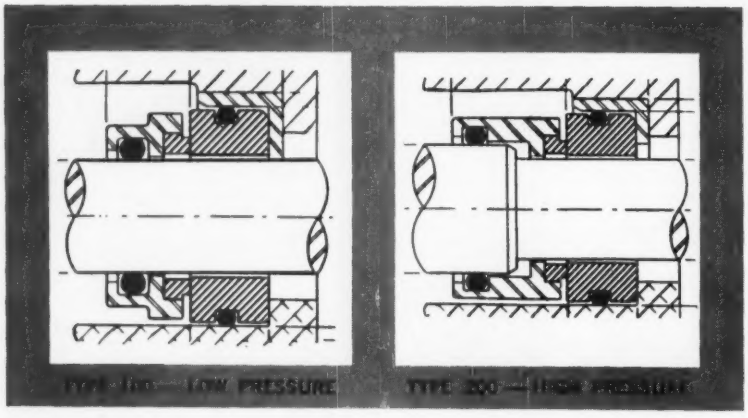
SEAL

ELIMINATES:

Springs
Set Screws
Spring Stops

Requires only 2 parts and two O-rings

First basic improvement in Mechanical Seals in 35 years



SIMPLE TO INSTALL — Self positioning — Does not require dismantling of pump. Magnetic attraction of sealing and mating rings eliminates use of springs. Up to 18 parts eliminated. Sealing contacts always positive and even. Seal is so thin it will fit in shallowest of boxes.

Complete brochure gladly furnished on request.

A. W. CHESTERTON CO.
7 ASHLAND ST., EVERETT 49, MASS.

America's Oldest Manufacturer of Mechanical Packings

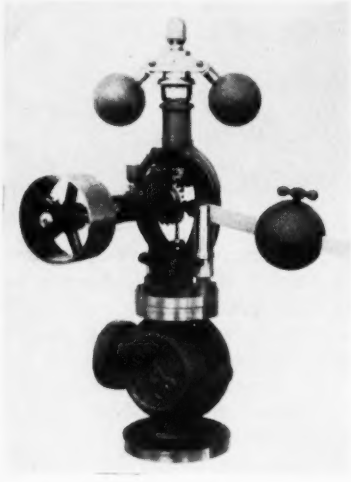
Reports from the field

Begins on page 188

Large radiation sources topic of Warsaw Conference

VIENNA, AUSTRIA (McGraw-Hill World News) Uses of large radiation sources is topic of an upcoming International Atomic Energy Agency conference. This will be the first international meeting to be held on the subject and its success will depend on the cooperation of scientists as well as the governments of member states.

Subjects to be discussed will be applications of radiation sources, reactors involved and problems incurred in work with these sources. Economics of radiation processing will also be discussed.



Gardner-Denver Company celebrates its centennial

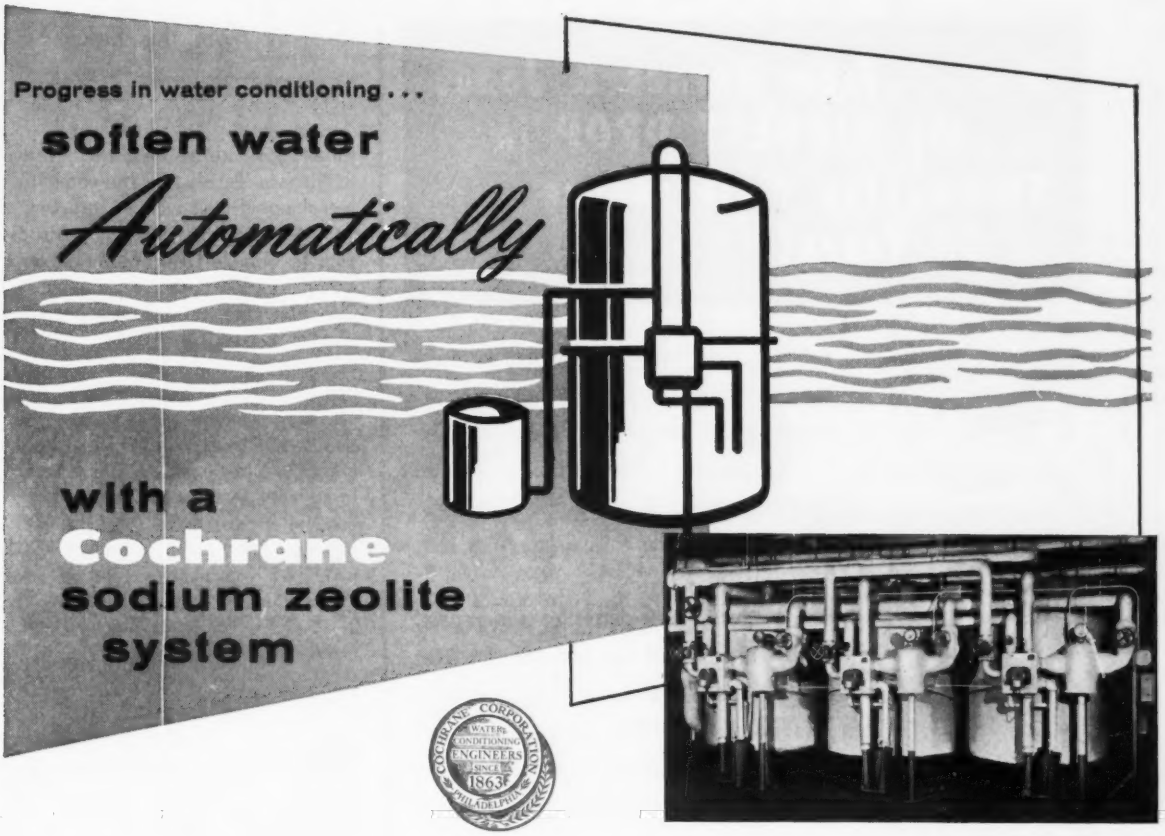
Gardner-Denver Company, a supplier of primary equipment to the world's basic industries, began 100 years ago when Robert W Gardner opened the doors of his one-room machine shop and foundry at Quincy, Ill.

In those days steam-engine use was restricted by lack of speed control—engines would break down, fly apart, run wild or even explode. Gardner's first product was a fly-ball governor, above, to help control engine speed.

By 1880, the Gardner Governor Company began to diversify its product line, adding steam pumps for general industry and later air compressors and power-driven pumps. In 1901, steam pumps were converted

Progress in water conditioning . . .

soften water *Automatically* with a Cochrane sodium zeolite system



The Sodium Zeolite process is the simplest, most popular means of converting hard water to soft water for industrial use. No chemicals are added, no precipitates formed, yet zero hardness water is produced.

Cochrane's exclusive Hydromatic Single Control Valve makes the Zeolite process even simpler, more reliable and more economical. This Single Control Valve takes the place of 6 or more gate valves of the old-fashioned design. Operation can be manual, semi-automatic or completely automatic.

Check these advantages of Cochrane Hydromatic Valves:

- The cast iron split-case valve body is new in design with removable cover. This permits larger, smoother internal passageways resulting in lower loss of head. It also permits easy access to the inner valves and seats without disconnecting piping.
- Inside the body are the six inner single seat diaphragm valves hydraulically actuated by a rotating multiport pilot valve. For automatic control a 40 watt motor drives the pilot shaft through a gear. These non-leaking, non-scoring inner valves with compressible rubber valve discs prevent contamination of treated water by brine or raw water.
- Automatic control of backwash and rinse flow rates even with variable raw water pressure—eliminates rate-of-flow controllers or float operated butterfly valves behind orifices in large concrete sumps.
- Slow valve action prevents hydraulic shock to zeolite or supporting bed and piping.

Wherever Sodium Zeolite Softening is indicated, Cochrane's experience and superior equipment design assure top performance. For more information on Cochrane Sodium Zeolite Softeners, write for Publication 4520-D.

Cochrane
CORPORATION
3106 N. 17th Street, Philadelphia 32, Pa.
Philadelphia • New York • Chicago
Cochrane Water Conditioning, Limited, Toronto, Montreal, Winnipeg, Canada.

Representatives in thirty-two principal cities in U.S., Hawaii, Puerto Rico; also Havana, Cuba; Paris, France; La Spezia, Italy; Mexico City, Mexico; Caracas, Venezuela; Santiago, Chile; Manila, Philippine Islands.

POTTSTOWN METAL PRODUCTS DIVISION—
Custom built carbon steel and alloy products.

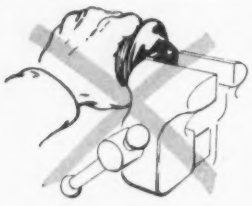
Demineralizers • Zeolite Softeners • Hot Process Softeners • Hot Lime Zeolite Softeners • Dealkalizers • Reactors • Deaerators • Pressure Filters
Continuous Blowoff Systems • Condensate Return Systems • Steam Specialties

For more facts circle 331 on Reader Service card, p 125

Now . . . from Barnes & Jones . . . the BIGGEST DROP in Steam Trap Maintenance in 50 Years!

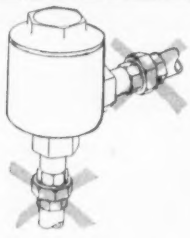
No parts — no assembly.

Barnes & Jones has been recognized for over half a century as a leader in thermostatic traps for the heating trade. Now — the same basic cage unit feature that revolutionized radiator traps thirty years ago is available for high pressure process steam applications.



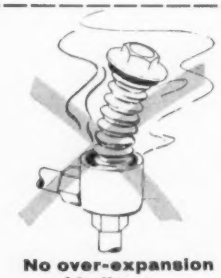
No special tools or shop required.

Now — costly, time-consuming steam trap repairs are outmoded. For with this new B-J Cage Unit replacement, you simply drop a complete new interior into the trap and it's new again. And if steam trap maintenance is a bugaboo with you — it's the best and biggest drop you can make.



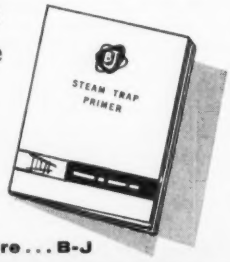
No need of unions.

Also — Barnes & Jones Cage Unit interiors are available to renew other makes of industrial traps.



No over-expansion of bellows.

If you're interested in saving steam, cutting repair and maintenance time and improving trapping efficiency, write today for "The Steam Trap Primer". You'll see the 'hows' and 'whys' of steam trap performances. And perhaps you'll see how B-J high pressure traps and cage units can end your steam trap problems.



Be Wise . . . Be Sure . . . B-J

Barnes & Jones, Inc.
36 Crafts Street
Boston 60, Massachusetts

Reports from the field

Begins on page 188

into "mud pumps" for rotary oil-well drilling in Texas, and the company's petroleum division came into being. In 1927 Gardner merged with the Denver Rock Drill Manufacturing Company, becoming a supplier for the petroleum, mining and construction industries.

Merger with the Keller Tool Company in 1955 and acquisition of the Mayhew Machine and Supply companies this year have brought Gardner-Denver a total of 13 manufacturing plants in four countries. It has become one of the 500 largest manufacturing corporations in America, with last year's sales totaling over $63 million.

Atomic heat exchanger shows serpentine tube maze

Intricate serpentine-involute tube pattern was chosen for the liquid-metal heated steam generators of 100,000-kw Enrico Fermi Atomic Power Plant to be erected at Lagoona Beach, Mich. Scale model, above, was unveiled at the recent Nuclear Congress and Atomfair.

Tube bundle was developed by The Griscom-Russell Company. It is designed to produce high-temperature high-pressure steam for electric-power turbine generators. Tubes are bent and trombone-nested in banks of eight. Each of the 150 tube banks is then formed into an involute plane. The three units will be over 26½ ft high with tubes set inside a cylindrical shell 106 in. in diameter.

THE WESTERN PRECIPITATION

"Transistomatic" CONTROL

BY FAR, the Industry's Most Advanced Precipitator Control...

NO TUBES! NO RELAYS! NO COUNTERS!

and carries a Lifetime Guarantee!

In the electrostatic precipitation of dust, fume and fly ash, no installation is completely modern without *automatic* control to maintain optimum Precipitator efficiency as the characteristics of the gas stream fluctuate. Compared with manual control, automatic control is not only more sensitive and more efficient, but actually costs less because of the vital savings it makes in labor and operating costs . . . *savings so important that no profit-minded operator will want to be without them.*

But the important point to remember is this— Although many manufacturers of precipitation equipment offer units for precipitator automation, no other unit is equal to the "Transistomatic" Control for foolproof simplicity, rugged dependability or control accuracy!

These are not idle claims. They can be easily verified by making your own comparison . . .

A DESCRIPTIVE BOOKLET *that gives further information will gladly be sent on request. Write, wire or phone our nearest office!*

Compare ACCURACY! The "Transistomatic" does not base its "sensing" action on spark *frequency* alone—or spark *intensity* alone. Instead, it continuously integrates BOTH frequency and intensity to establish an overall "power value" that provides a new standard of control accuracy!

Compare DEPENDABILITY! The "Transistomatic" unit contains no parts of any kind requiring regular replacement. Moreover, the entire unit is completely sealed—moisture-proof and watertight.

Compare GUARANTEES! The "Transistomatic" is so foolproof and trouble-free it carries *a lifetime guarantee!*

BEFORE YOU BUY ANY automatic precipitator control, be sure to get the complete "Transistomatic" story. A folder is available giving additional data. Or see your nearest Western Precipitation representative for further details!

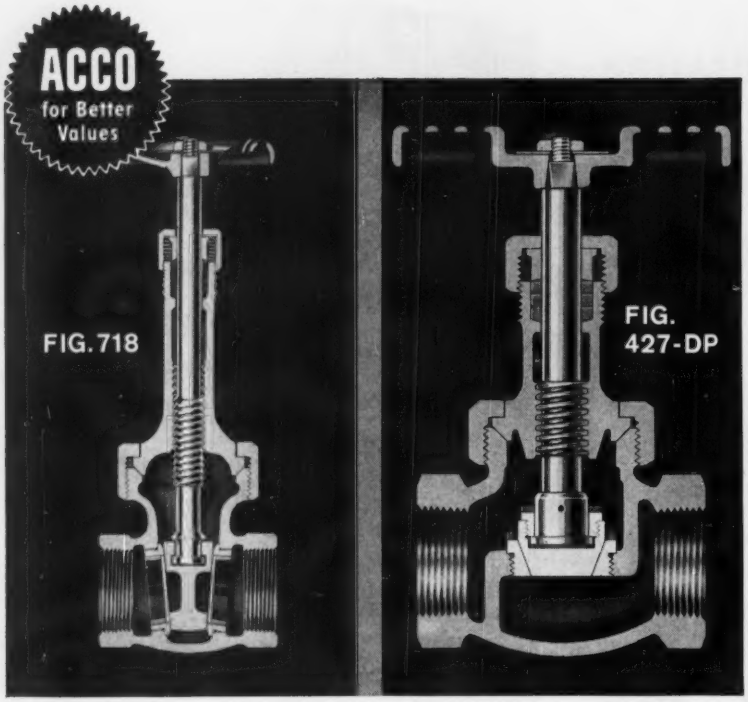
WESTERN PRECIPITATION CORPORATION

Engineers and Constructors of Equipment for Collection of Suspended Material from Gases . . . and Equipment for the Process Industries

LOS ANGELES 54 • NEW YORK 17 • CHICAGO 2 • PITTSBURGH 22 • ATLANTA 5 • SAN FRANCISCO 4

Representatives in all principal cities

Precipitation Company of Canada Ltd., Dominion Square Bldg., Montreal



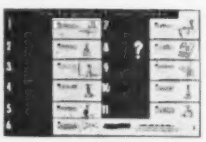
Why R-P&C bronze valves give longer service life!

Here are some of the advantages you get when you use R-P&C Bronze Valves—either globe or gate style:

1. **Renewable seat rings, screwed in for greatest convenience**
2. **Higher resistance to galling and pitting, because stems are made from special rolled "Coradur" bronze**
3. **Easier maintenance, thanks to the union bonnet which permits easy internal servicing when needed**
4. **Added ease of operation, due to the rugged, air-cooled, cross-type handle**

All these, and many other features, add up to a longer and more trouble-free life of R-P&C Bronze Valves for steam, water, oil and/or gas service.

Shown above are two examples from the R-P&C line of Bronze Valves: Fig. 718 (gate) and Fig. 427-DP, a full-plug globe valve. Your R-P&C distributor can furnish complete information on the entire R-P&C line of valves, not only in bronze, but in electric furnace iron, cast steel, bar stock and forged steel. See him—or write us direct for catalog.



FREE WALL CHART

"How to Protect Your Valves"

Installation pointers, operating tips, clues to longer valve life. They all are on the 22" x 17" wall chart. Write us at Reading, Pa., for your free copy.

R-P&C VALVES

ACCO

R-P&C Valve Division, American Chain & Cable Company, Inc.

Reading, Pa., Atlanta, Boston, Chicago, Denver, Detroit, Houston, New York, Philadelphia, Pittsburgh, San Francisco, Bridgeport, Conn.

Appointments

Corporation changes

Westinghouse Electric Corporation: M W Cresap Jr, president and chief executive officer; G A Price, board chairman. **The Marley Company:** L T Mart, board chairman; J A Cameron Jr, president; M A Patton, vice-president, research and development.

Hale Fire Pump Company: E J Wendell, board chairman; J S Bennett, president. **Walworth Company:** J C Wallace, president; Harold Brown, vice-president and general sales manager; F W Belz, board chairman.

Schenectady Varnish Company, Inc: H D Wright, president; C A Braidwood, vice-president. **National Ultrasonic Corporation:** L R Jeffrey Jr, president and general manager. **Stanford Research Institute:** E F Carter, president; W B Gibson, vice-president. **National Aluminate Corp,** Overseas Div: W H Thompson, assistant vice-president for Europe. **Sylvania Electric Products Inc:** A L B Richardson, vice-president.

Operations changes

The Babcock & Wilcox Company, Tubular Products Div: J S Anderson, general manager. **H K Porter Company, Inc,** Leschen Wire Rope Div: G N Dow, general manager. **The Electric Products Company:** W H Lee, director of research and engineering.

Walworth Company: John Alico, manager of manufacturing. **Consolidated Diesel Electric Corporation,** Con Diesel Western facility; E N Gomberg, general manager. **General Electric Company,** Gas Turbine Dept: C W George, engineering manager. **Link-Belt Company,** Chicago operations: E P Berg, general manager.

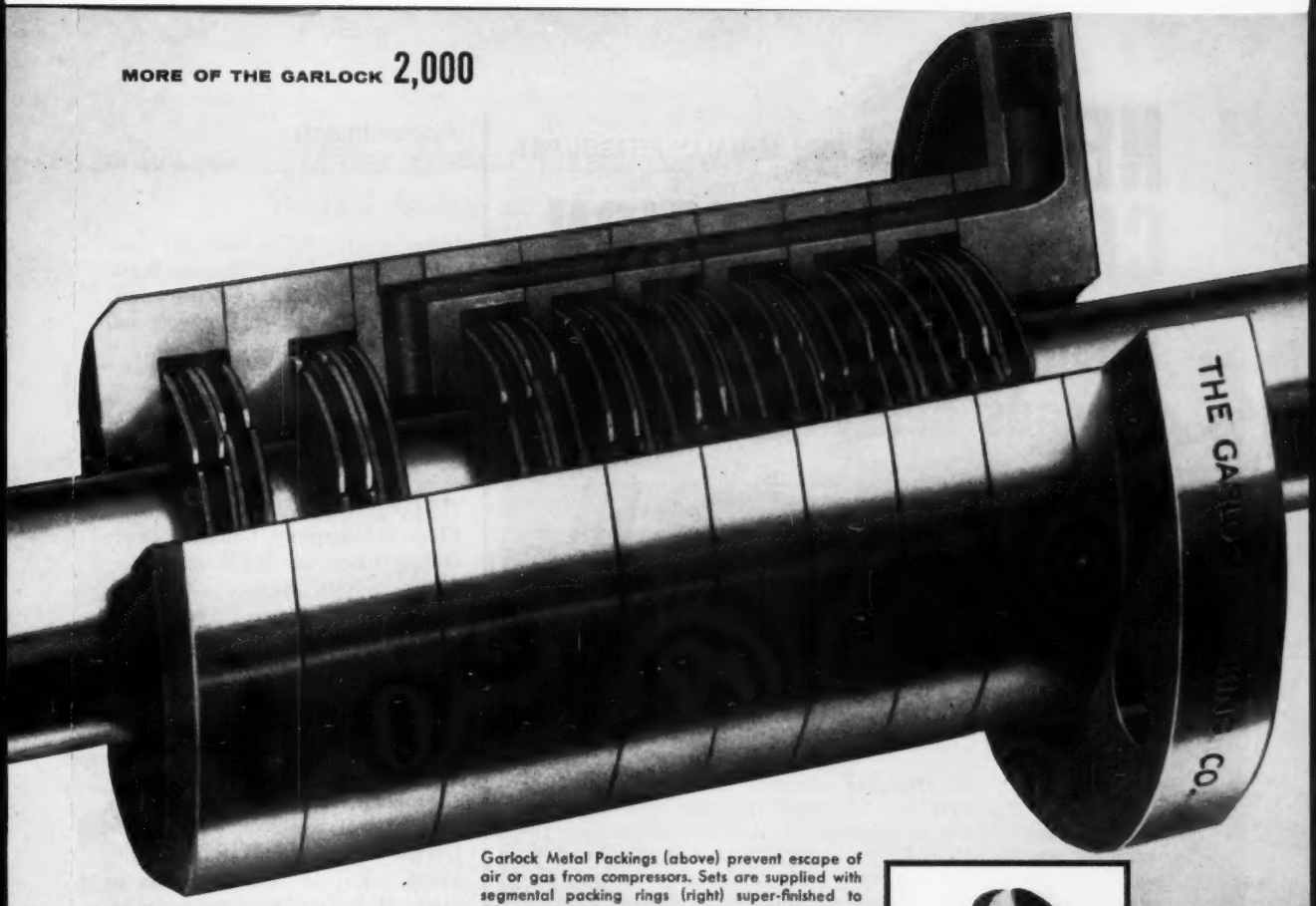
Taylor Fibre Company, La Verne plant: P V Brown, manufacturing manager. **United States Rubber Co,** Gilmer plant: W H Onderdonk, manager.

North American Aviation, Inc, Atomics International Div: C C Conners, construction manager of nuclear-

For more facts circle 334 on Reader Service card, p 125

circle 335 on Reader Service card, p 125 ➤

MORE OF THE GARLOCK **2,000**



Garlock Metal Packings (above) prevent escape of air or gas from compressors. Sets are supplied with segmental packing rings (right) super-finished to 15 micro-inches or less for better sealing.

Seal air and gas compressors this proven way... with Garlock Metal Packings

Every metal packing set that leaves the Garlock factory must meet the following rugged standards:

1. Gas tight seal between packing rings and compressor rod.
2. Gas tight seal between packing rings and packing groove.
3. Packing must not be affected by operating conditions.
4. Operating conditions must not be affected by packing.
5. Packing must have no adverse effect on compressor rod.

Get these fine features by specifying Garlock metal packings. Choose from many different styles and materials. Whichever you select, you can be sure of the finest metal packing available for air and gas compressor service.

Metal packings and oil scraper rings are more of the Garlock 2,000 . . . two thousand different styles of packings, gaskets, and seals for every need. Assure yourself of the proper application by discussing it with your local Garlock representative. Call him, or write

THE GARLOCK PACKING COMPANY, Palmyra, N.Y.

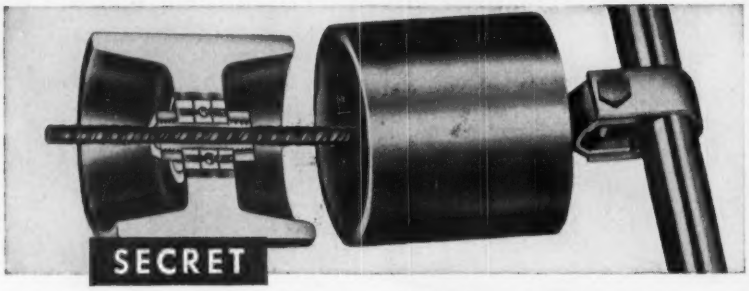
For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U. S. and Canada.

GARLOCK

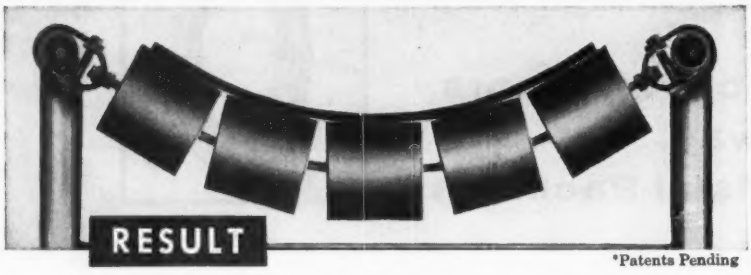
Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products

Canadian Division: The Garlock Packing Co. of Canada Ltd. Plastics Division: United States Gasket Company

NEW (EXCLUSIVE WITH McNALLY PITTSBURG) CONVEYOR DESIGN ... slashes maintenance cost! ... extends belt life!



. . . of the amazingly improved efficiency of this modern belt conveyor is shown here. This new McNally Pittsburg Cradle Idler* consists of 5″ rubber rollers assembled on precision ground ball bearings, prelubricated and lifetime sealed. Being a *true catenary* suspension with rollers mounted on flexible, *non-rotating* stainless steel wire rope, this design eliminates "loping" and dangerous harmonics.



*Patents Pending

. . . is greater capacity and faster belt operation with minimum spillage. Since the belt lies in true arc with no creases or bends to cause wear, *belt life is substantially increased.* Because this McNally Pittsburg conveyor design is so simple, costs are lower, and erection time is reduced.

WRITE TODAY | for details on the new conveyor which costs less to install . . . *saves money every day it is in use.*

McNALLY · PITTSBURG

McNally Pittsburg Mfg. Corp.
Dept. PO, Pittsburg, Kansas

☐ Please send information on the new McNally Pittsburg belt conveyor.

☐ Have Sales Engineer call for further consultation.

Name_____ Title_____

Company_____

Address_____

City_____ State_____

Appointments

Begins on page 198

power reactor being built for Consumers Public Power District. **Westinghouse Electric Corporation,** atomic power dept: Dr W E Johnson, projects director.

Engineer changes

Wheelabrator Corp: H F Schulte, chief engineer. **J E Lonergan Co:** H I Gregg, design engineer. **General Electric Company,** Computer Dept: Dr G E Adams and R J Noorda, operations analysts. **Keasbey & Mattison Company,** Research & Development Dept: J C Butler, staff chemist. **Essex Conveyors, Inc:** George Cory, chief engineer.

Sales vice-presidents

Diamond Power Specialty Corporation: W H Jackson. **The Fluor Corporation, Ltd:** J P Kneubuhl, utility sales; G H Dieter, foreign sales; D S Tappan, domestic sales. **Maurey Manufacturing Corporation:** R B Malloy, vice-president in charge of sales; J F Taylor, assistant vice-president.

General sales manager

Westinghouse Air Brake Company, Le Roi Div: R H Koehler. **Cummins Engine Company, Inc:** G L Bego, director of sales services. **The Swartwout Company,** Ventilation Div: Robert Parshall.

Nordberg Manufacturing Company, Engine Div: C E Dietle. **Sperry Products, Inc:** H T Lowell Jr. **William Brand & Co, Inc:** C R Riorden, director of sales.

District sales manager

Link-Belt Company: G E Austin, Spokane, Wash. **OPW-Jordan:** C A Ault, northwest. **Dodge Manufacturing Corporation:** Paul Keb, North and South Carolina. **Torit Manufacturing Company:** Richard Bennett, Chicago. **Pittsburgh Standard Conduit Company:** J D Logan, eastern region.

Dresser Industries, Inc: Roots-Connersville Blower Div: W L Nopper, New York; R G Nancarrow,

The plant that never shuts down can't take a chance on Steam Traps

by John W. Ritter, Test Engineer
SARCO Company, Inc.

It pays to take a careful look at the economics of the whole problem of steam trapping. This is particularly true where a plant is operating continuously.

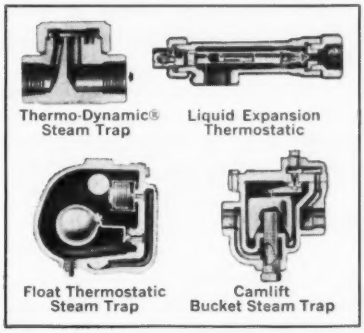
Twenty-four hour, 7-day production can be a mixed blessing. There is a great satisfaction in working to full capacity, but it doesn't leave much time to keep the equipment in first class working order. If major repairs or replacements become necessary, the partial shut-down that results can disorganize the whole output schedule.

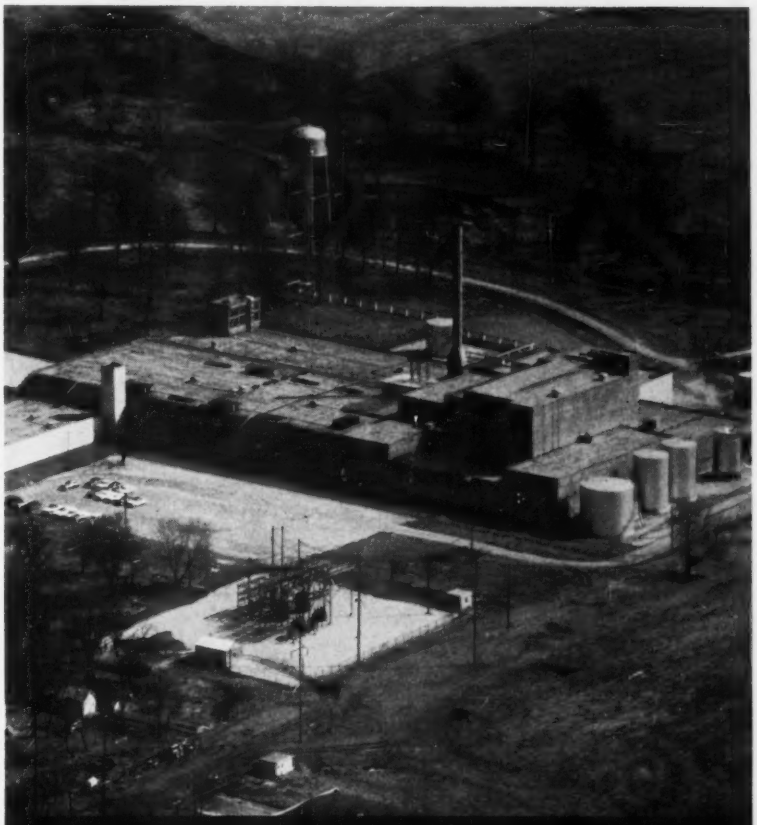
Some steam traps are much easier to maintain than others, and it pays to look into this easy maintenance feature of traps as carefully as you examine their operating characteristics.

Another important point in steam trap selection is to be sure the right trap is chosen for each job. Plant engineers know the operating conditions and if new questions arise on which they want supplemental consultation, they can have their questions answered without cost or obligation by a group of men who have real depth and breadth of experience in *production planned* steam trapping – Sarco engineers. Sarco advice is always impartial advice, because Sarco makes all five types of steam traps.

Sarco engineers, for example, can demonstrate the economy of the Sarco TD-50, which is as near maintenance-free as a steam trap can be. They can show the special values of the Sarco Thermostatic, which requires no adjustment over a 300 psi operating range. There are any number of uses for the continuous discharge of the Sarco Float-Thermostatic particularly when closely controlled temperature must be maintained.

For every steam trapping need there is one best steam trap, ideal in its operating functions and built for an absolute minimum of required service and maintenance. Studying your individual plant needs in steam trapping, and filling these needs with the traps best suited to do their respective jobs will pay out handsomely in your production and operating records.





At the ultra-modern new casing plant of Tee-Pak, Inc. at Danville, Illinois, Sarco Steam Traps of four different basic types are widely used.

At Tee-Pak's new casing plant they depend on SARCO Steam Traps to help prevent down-time

Twenty-four hours a day – seven days a week. That's the operating schedule at the modern new Danville, Illinois, plant where Tee-Pak produces its cellulose casings. Requiring dependable operation from all equipment, the company has used four different types of Sarco Steam Traps, each selected to do a reliable, trouble-free job in its particular application.

When you have a steam trapping problem, whether it's a single installation or dozens of different applications, consult your local Sarco representative or write Sarco directly for impartial advice on *Production Planned* steam trapping, because . . .

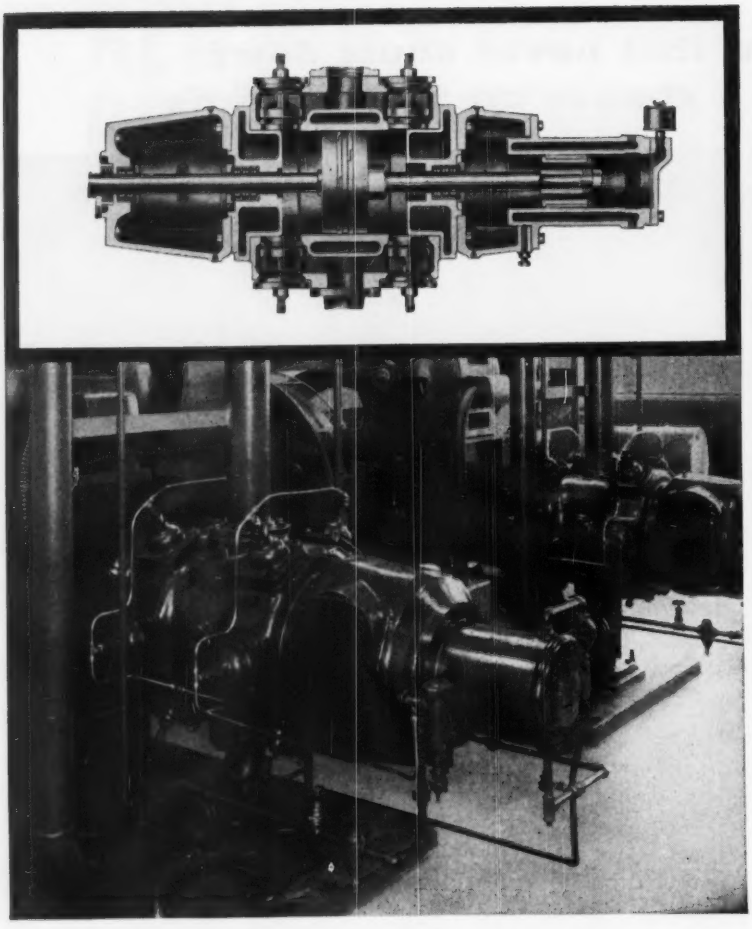
7945

SARCO
COMPANY, INC.
635 Madison Ave., New York 22, N. Y.

Only Sarco makes all 5 types:
Thermo-Dynamic • Thermostatic • Liquid Expansion
Float Thermostatic • Bucket

STEAM TRAPS • TEMPERATURE CONTROLLERS • STRAINERS • HEATING SPECIALTIES

For more facts circle 337 on Reader Service card, p 125



with PENNSYLVANIA tailrod construction,

COMPRESSORS PROVIDE GUARANTEED OIL-FREE AIR...eliminate contamination

If your processes stand the chance of being ruined by the least contamination, better look into Pennsylvania Oilfre Compressors today. They are built specifically to eliminate any lubricant or oily vapor which would interfere with delicate instruments, contaminate food and beverages or be incompatible with chemical processes.

*Pennsylvania Oilfre construction is one reason that we can guarantee oil-free compressed air or gas. An extra long distance piece between compressing cylinder and main frame assures that no part of the piston rod which enters the lubricated frame will alternately enter cylinder stuffing box. Result: a compressor with isolated cylinder which will deliver air or gas guaranteed entirely free of oil or oily vapors due to lubricants. Pennsylvania tailrod construction produces a full floating piston which prolongs the life of carbon piston rings and eliminates the danger of piston riding against cylinder walls.

Get full details on Pennsylvania 3-ATC Compressors. Send for free copy of Bulletin 351, today.

PENNSYLVANIA PUMP AND COMPRESSOR CO.

Easton, Pa. • Earning customer confidence since 1920

Appointments

Begins on page 198

Philadelphia. **North American Manufacturing Company,** Hydraulic Controls Div: R J Matteson, east.

Recent purchases, mergers

Hydrometals, Inc: purchase of Midwest Metals, Inc, wholly owned subsidiary of the Fluor Corporation, Ltd. **North American Aviation, Inc:** plans to acquire Foster Wheeler Corporation.

The Ohio Brass Company and its wholly owned subsidiary, **Holan Corporation:** purchase of Universal Hydraulics, Inc to operate as Holan's subsidiary. **The Electric Storage Battery Company:** purchase of American Machine & Foundry Company's Battery Laboratory. **Dodge Manufacturing Corporation:** acquisition of a 40% interest in Fenner Dodge (Australia) Pty Ltd.

Recent moves

The Johnson-March Corporation: to 3018 Market St, Philadelphia 4, Pa. **Opad Electric Company:** to 43 Walker St, New York 13, N. Y. **General Electric Company,** Conduit Products Dept: to Niles, Ohio.

Awards

P L Alger, recently retired from General Electric Company, and **Sterling Beckwith,** consulting engineer: Lamme Gold Medal of the American Institute of Electrical Engineers.

Dr J R Dunning, dean of Columbia University School of Engineering: Columbia's Michael I Pupin Anniversary Medal.

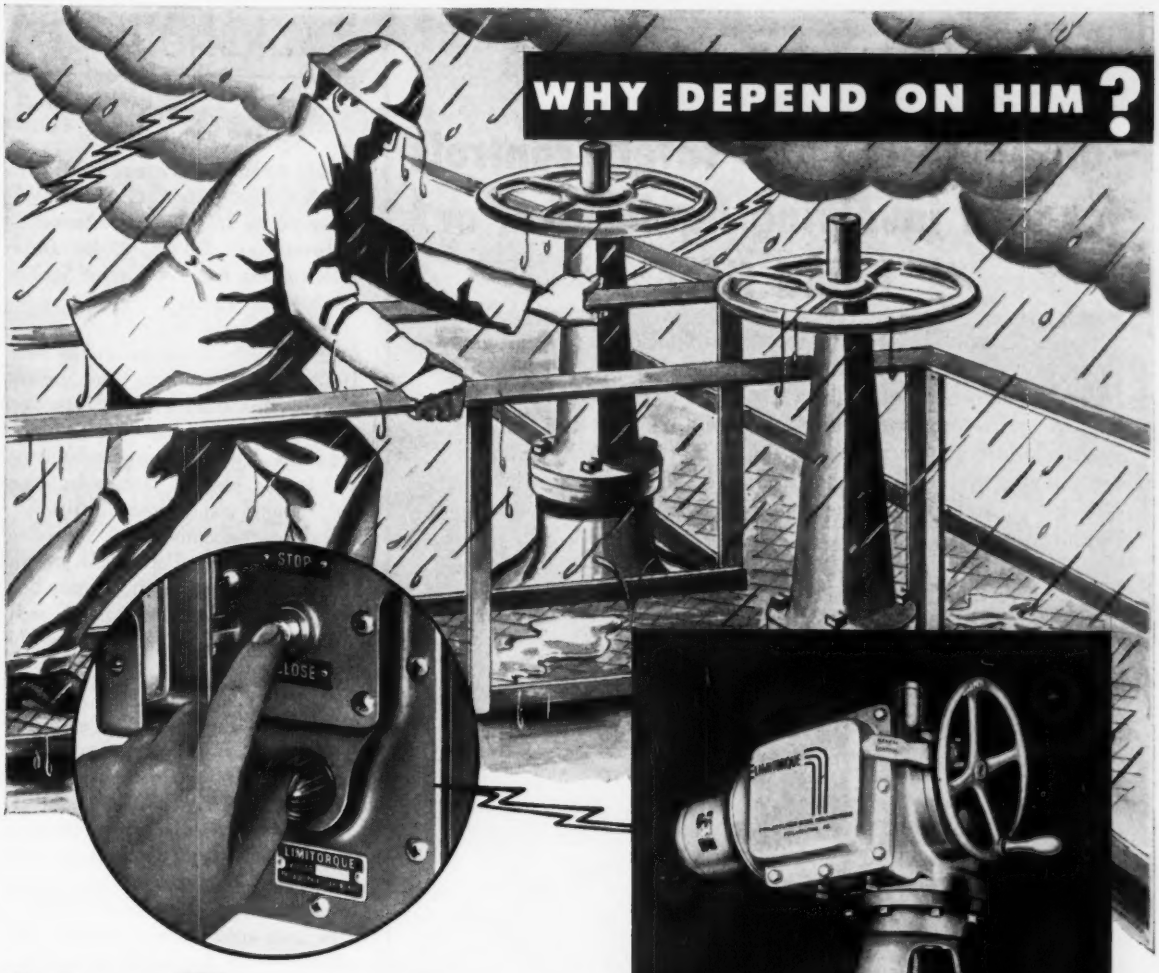
Dr G T Seaborg, Nuclear Science and Engineering Corporation: appointment to the President's Science Advisory Committee.

Retirements

J F Anderson, vice-president of Continental-Diamond Fibre Corporation, after 47 years of service.

R R Donaldson, board director and vice-president of engineering for Hagan Chemicals & Controls, Inc, after 40 years of service.

P L Alger, General Electric Company, after 40 years of service.



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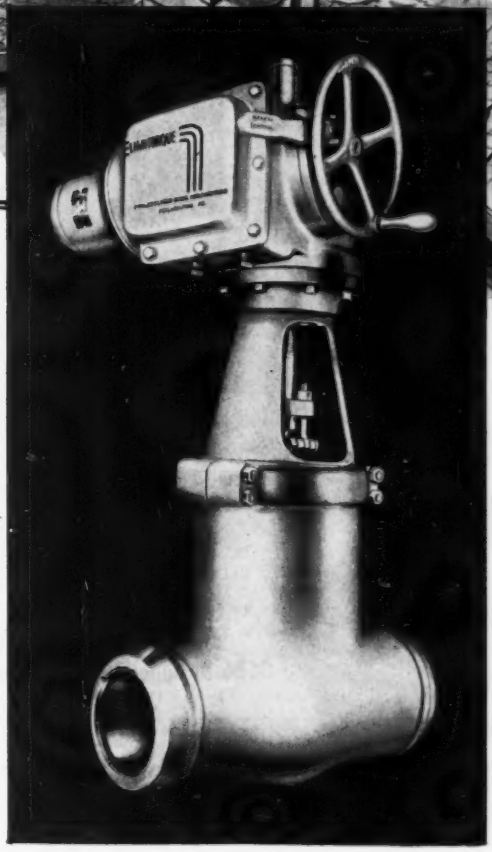
WILL DO IT THE EASY, SAFE WAY

Whether hand operating conditions of valves involve snow, ice, slush, high winds, torrential rains, high temperatures and dust storms, or climbing to high, inaccessible and hazardous valve locations—LIMITORQUE PROVIDES COMPLETE SAFETY TO WORKMEN, because it operates valves automatically by the "mere push of a button," from a centrally located panel-board . . . and, what is also vitally important, LIMITORQUE PROTECTS VALVE OPERATING PARTS by a torque limit switch, which instantly shuts off the motor if obstructions are met during valve operation. . . . Yes, it will pay you to equip your hand-operated valves with LimiTorque Motorized Valve Operators.

Contact your Valve Manufacturer, or your nearest LimiTorque Sales Engineering Office.

Send for Catalog L-550 and please use your Business Letterhead.



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INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID AGITATORS • FLEXIBLE COUPLINGS

Limitorque Corporation • Philadelphia

For more facts circle 339 on Reader Service card, p 125

NEW DATA —

—on operating and safety controls for jobs involving liquid level or liquid flow

This new book shows how McDonnell float-operated switches and valves, and flow switches, can be used to provide dependable, economical control for a wide variety of applications.

On hydro-pneumatic tanks, for example, or water chillers; with standby pumps and surge tanks; in water supply and proportioning systems. All in all there are 21 case studies in this book . . . and each one can suggest dozens of other specific applications.

To learn a lot of answers to a lot of frequently-encountered liquid level and flow control problems get your free copy of this new Bulletin ERS-A.

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Bookshelf

Guide to the Literature of Mathematics and Physics. *By Nathan Grier Parke III, Parke Mathematical Laboratories. 436 pp, $2.49. Dover Publications, Inc, 180 Varick St, New York 14, N. Y.*

Good research begins with a thorough study of literature in the field. Designed for students and professionals, this bibliography lists over 5500 key works under 120 subject headings. Titles are cross-referenced, and in the case of foreign-language publications translations are listed.

Indexes, documentary reproductions, abstracts and other aids are included. One feature is an up-to-date compilation of agencies and individuals engaged in Russian-translation programs.

Kempe's Engineers Yearbook (1959). *Two volumes in case, 3000 pp, 82/6d. Morgan Brothers Ltd, 28 Essex St, Strand, London W C 2.*

In this latest revision of a timesaving reference work, chapters on flowmetering and mechanical testing, refrigeration and paints and varnishes have been completely rewritten. Two volumes make up a complete library covering modern theory and practices in all branches of engineering. Mechanics, electrical engineering, thermodynamics, hydraulics, materials handling, lubrication, gas turbines, fuels, atomic power and patents are some topics included in 79 chapters. A comprehensive index contains about 17,000 references

Engineering Thermodynamics. *By C Osborn Mackey, Head of Department of Thermal Engineering, Cornell University, William E Barnard (deceased) and Frank O Ellenwood (deceased). 428 pp, illust, tables, 6 x 9¼, cloth, $7.95. John Wiley & Sons, Inc, 440 Fourth Ave, New York 16, N. Y.*

This book represents the modernization of the original three-volume *Heat-Power Engineering* by Barnard, Ellenwood and Hirshfeld. Like most present-day thermodynamics books this one also follows the trend of demonstrating the application of thermo relations to practical equipment. Be-

Underground hot pipes stay free from trouble...when you INSULATE WITH GILSULATE

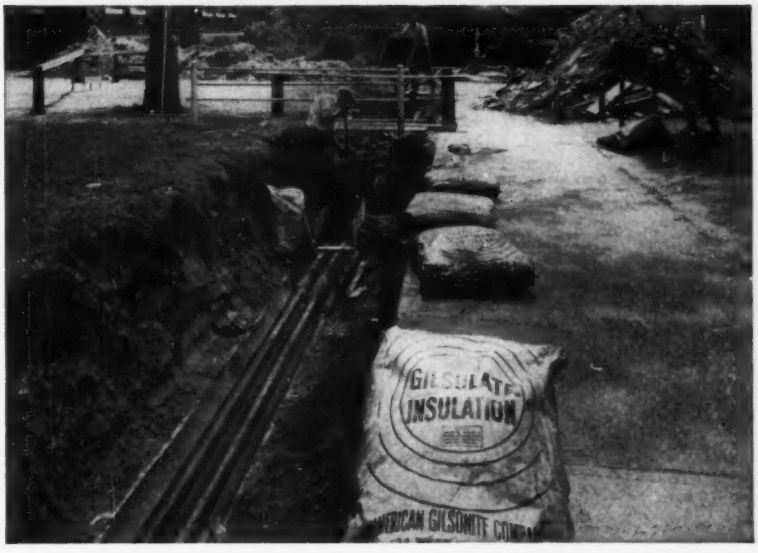
One of the most difficult problems in designing underground hot piping systems is providing positive corrosion protection against electrolytic, chemical or galvanic attack. The answer lies in the use of GILSULATE. For, in addition to its excellent insulating properties, this naturally-occurring hydrocarbon is chemically neutral in all soils, dielectric, and moisture-proof and water-proof as well.

GILSULATE's low thermal conductivity, low cost and easy installation make it possible for schools, colleges, housing projects, hospitals, industrial plants and other institutions to install central heating with underground piping and to realize the savings in equipment and operating costs which such systems provide.

We'll help you with your plans

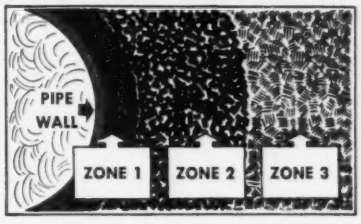
If you are planning to rehabilitate present piping, or to install a new underground hot piping system, it will pay you to contact your nearest GILSULATE Distributor. His own extensive experience in the field of heating, piping and air conditioning, plus the research, engineering and field supervision facilities of the American Gilsonite Company are at your disposal...without obligation. They will work with your engineers in checking specifications, unusual soil conditions, and actual installation to make sure that the finished job is completely satisfactory.

If you would like complete information on GILSULATE insulation, or would like to be put on the mailing list to regularly receive free copies of PIPE INSULATION NEWS, send your request to any of our offices.



GILSULATE IS EASY AND ECONOMICAL TO USE

GILSULATE completely frees you of the expensive, time-consuming preparation required by many insulating systems. You just pour it into the pipe trench, shovel-point it around the pipes, and tamp it. Pipe heat does the rest.



Heat fuses the GILSULATE to pipes and joints to form three zones: Zone 1, a flexible, heavy-duty water barrier; Zone 2, of firmly-cemented granular GILSULATE that provides excellent thermal insulation under wet or dry conditions; and Zone 3, which provides a final zone of thermal insulation and a support for the water-proof structure.

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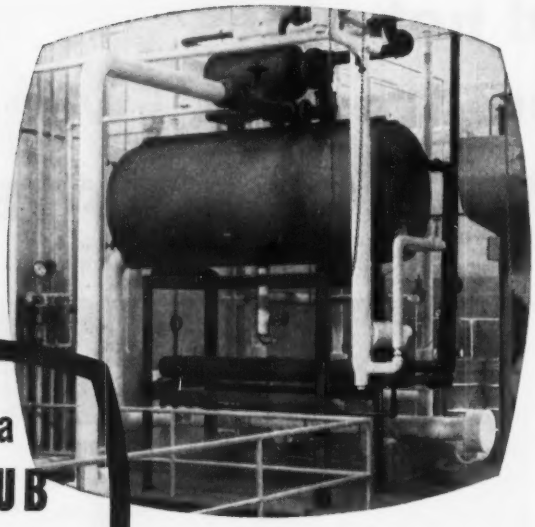

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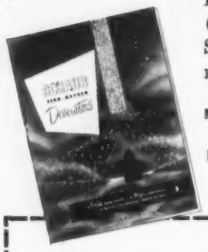
you DON'T NEED sodium sulphite!

True boiler system corrosion protection ...oxygen removal to .005 cc/liter actually achieved under all load variations

The plain fact is, if you have to add something like sodium sulphite to a deaerator for final scavenging of oxygen, you just aren't getting full deaeration. (And you *could* get some bad side effects, worse than the oxygen itself.)

The unique Schaub principle employs 1) external "superheating" to *above* boiling point in the deaerator . . . 2) "explosive" flash-down to release all dissolved gases . . . and 3) fully vented operation. This completely eliminates the air-fill problem and *thermal efficiency compromise* common to all conventional design deaerators using internal heating and restricted vent. *For you* this adds up to *actual* "zero" oxygen removal (to .005 cc/liter) with excellent thermal efficiency under wide load variations — with no need for "additives"

Further, it's a simple, *fully safe* system that takes less maintenance and attention, requires less head room, has fewer internal parts, and no "pressure shell" *insurance premiums to pay*. And exclusive Chromasoid lining guarantees against shell corrosion failure for 10 years!



For new installations or added deaerating capacity (up to 125,000 lbs./hr.) get the facts on the SCHAUB Zero-Oxygen *now* — from your Schaub representative or Write for Bulletin 575.

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Bookshelf

Begins on page 204

cause of the much more limited space, the present book cannot cover the practical application with the same detail that was so admirably done in the original series.

The book devotes six chapters to the basic principles and mathematics (up to partial differentials) of the subject. The book then applies these in following chapters to one-dimensional flow of ideal gases, gas mixtures, ideal-gas reactions, gas compression, engine cycles, vapors. turbines, power cycles of vapors, refrigeration and air conditioning.

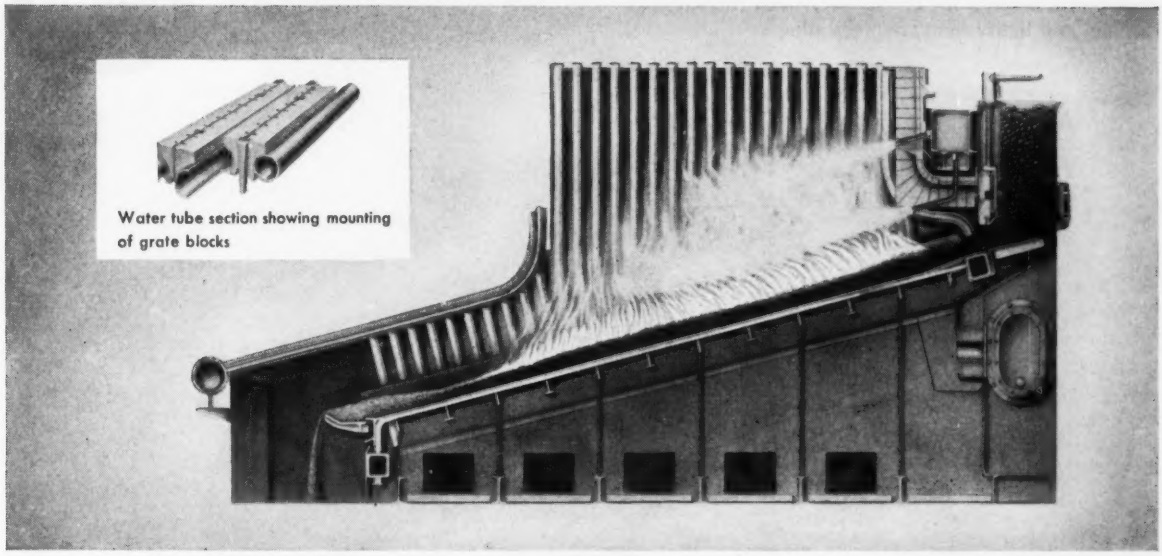
Smokeless furnace combustion system has been patented by Wilhelm Kaiser in Thierstein, Germany. Coal, coke, wood can be used, with all smoke and soot completely combusted.

Company image is a key factor in attracting engineers to jobs, report Deutsch & Shea, Inc, manpower consultants. Image is based on rumor, advertising, use of company products.

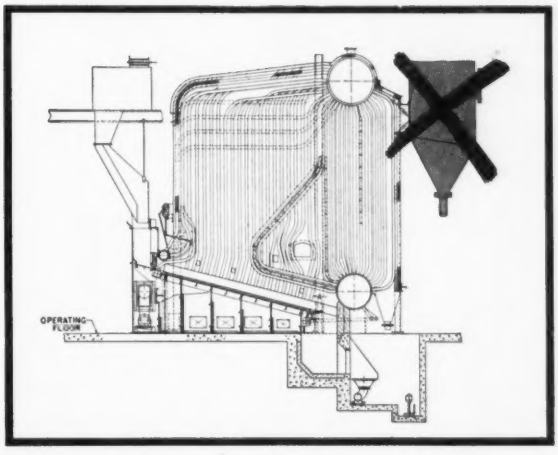
Engineering products totaled 40% of all Swedish exports to the U. S. in 1957 and were prominent in other dollar markets. Total to all markets was 55%, compared to 12% in 1938.

"Did you come across that small package marked 'Danger'?"

Only AE Vibra-Grate Stokers give you these 3 important benefits



Water-cooled grates. Water-cooling . . . directly connected to the boiler circulation system . . . guarantees the longest grate life available in any stoker today. Proven maintenance costs are less than one cent per ton of coal. In fact, one major installation has used less than $200.00 worth of repair parts in over four years of continuous operation!



Elimination of dust collectors and cinder return systems. Vibra-Grate burns the coal on the grate . . . dust collection and cinder return systems are not needed. You will never have to be selective in the grade of coal you burn either. Vibra-Grate feeds wet or dry fuel, high or low grade coals. It can burn gas or oil singly or in combination with coal. Overfire air assures complete combustion, giving absolute freedom from smoke at high or low ratings.

Higher efficiency. Intermittent vibrating motion of the grate feeds and moves the fuel . . . insuring even, compact distribution on the bed. A combustion-controlled electric timer determines the vibration frequency as required by fuel and steam demand. There are no light spots or holes to reduce efficiency. The grate supports form air-tight zoned sections dampered to permit accurate regulation of undergrate air.

THE AE VIBRA-GRATE offers advantages in stoker operation and efficiency that have never been available before, because it is the only stoker which combines the maintenance saving features of water-cooling and the high efficiency features of a vibrating grate and controlled zone undergrate air. Only from Vibra-Grate can you get such dramatic reductions in maintenance costs . . . as well as efficiencies that can't be equalled. Write for complete information on what Vibra-Grate stokers can do for you in terms of lower operating costs. American Engineering Company, Dept. S-100, Philadelphia 37, Pa.

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Choice of the leaders: K&M high-pressure insulations

Where temperatures range up to 1350°F., you'll find leaders in all fields where heat control is important turning to "K&M" KaytherM. Because they can be *sure* with "K&M" KaytherM. There's no better insulation of its type. In low-pressure insulations, it does everything "85% Magnesia" does, and does it better. Composed of diatomaceous silica and quality asbestos fibers, "K&M" KaytherM is easily worked on the job, chemically stable, strong, and lightweight. Cement adheres readily.

"K&M" also manufactures a full line of Low-Pressure Insulations in pipe, sheet, and block forms, as well as in cements for all types of applications.

Whatever your insulation problems, you can rely on the eighty-five years of asbestos engineering that lies behind every "K&M" asbestos product.

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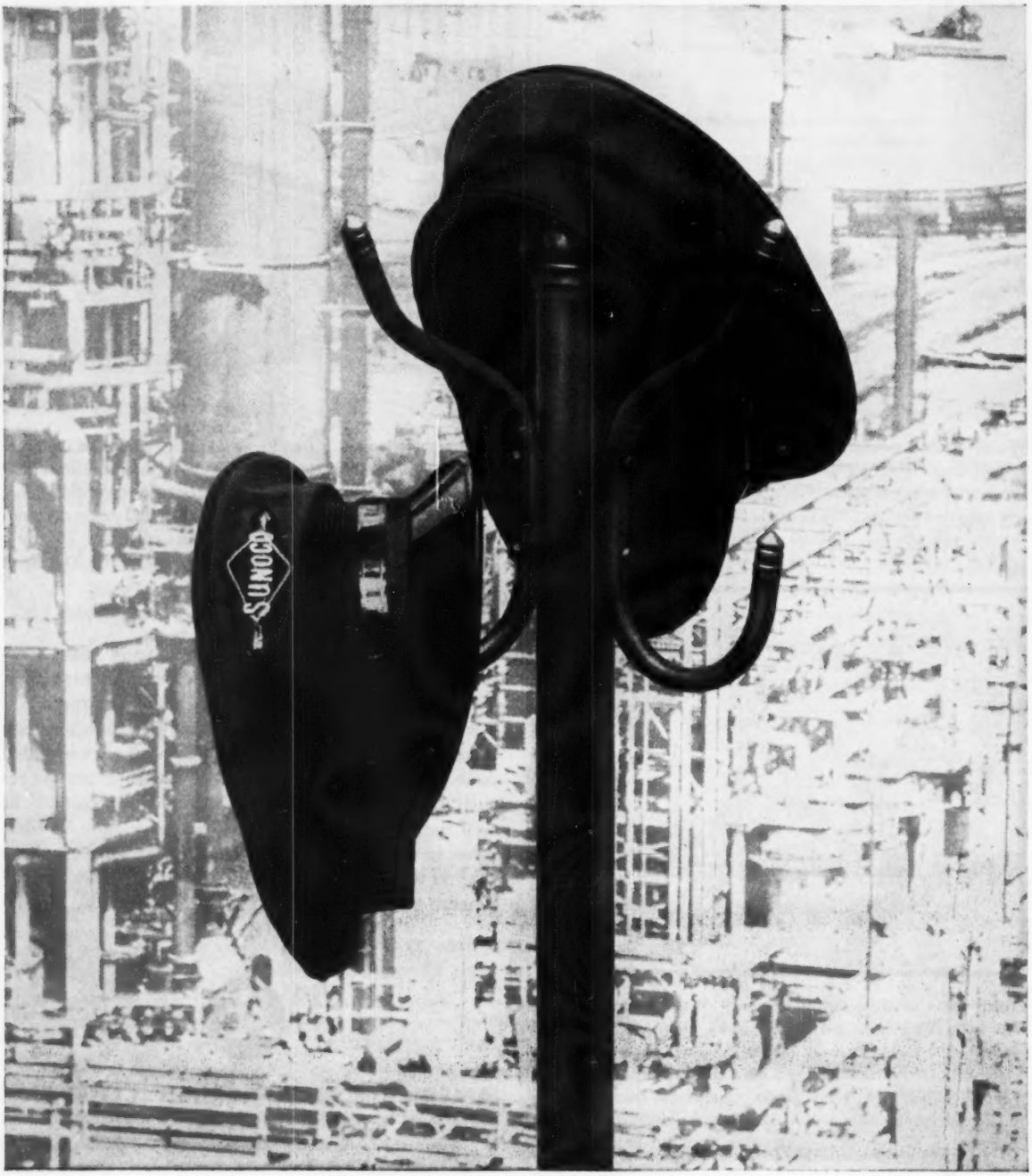

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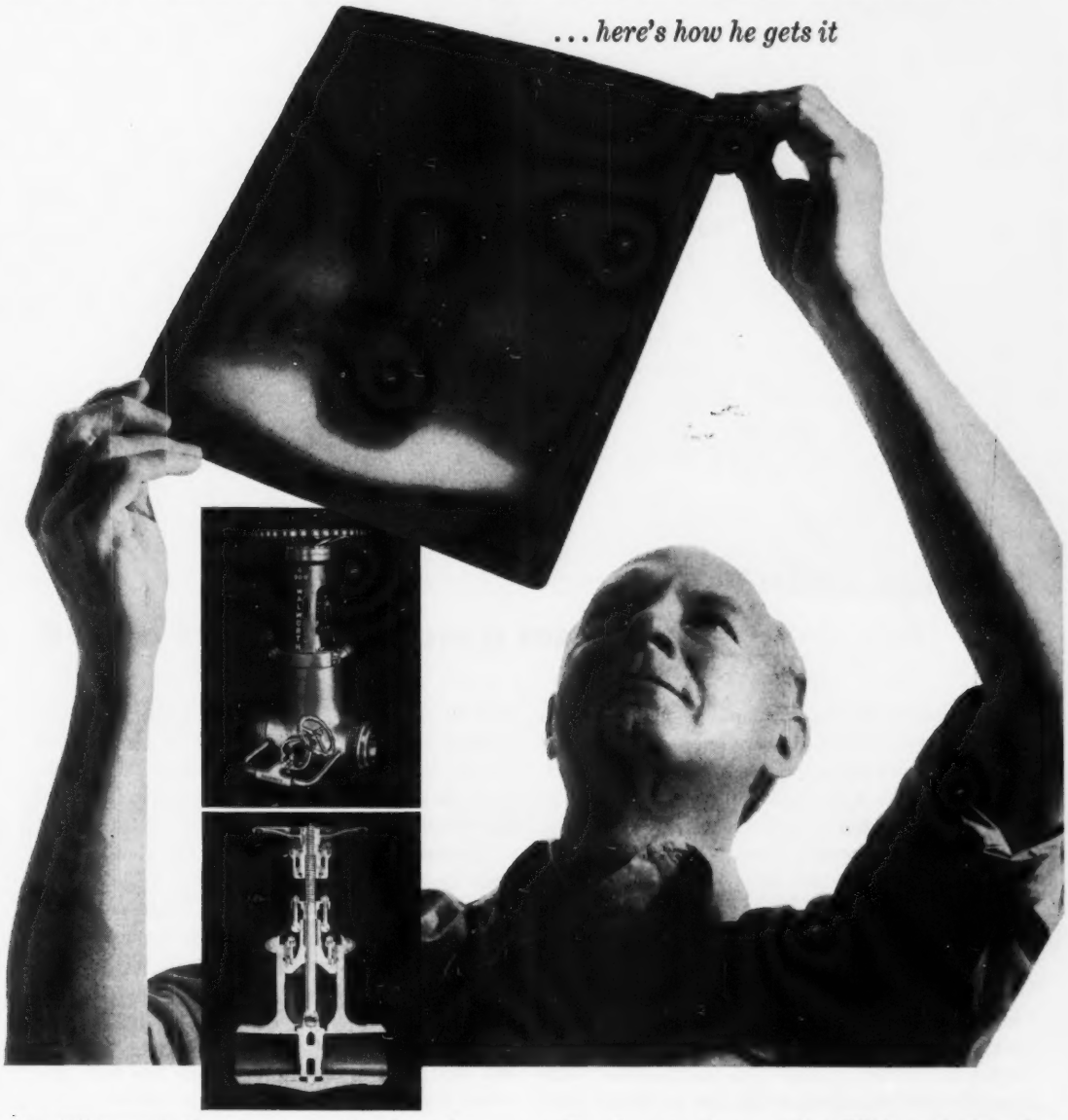
the **WALWORTH CUSTOMER** *gets*

VALVE SOUNDNESS THROUGH RADIOGRAPHY

. . . here's how he gets it



When the Walworth Customer needs valves for high-pressure, high-temperature steam service or boiler feed service, he wants to know about quality control: is every single valve thoroughly examined and tested to insure long, safe operating service? When he studies Walworth Pressure-Seal Steel Valves, he learns that *every* pressure containing casting of *every* Walworth Pressure-Seal Valve is completely radiographed.

Further, he learns that Walworth foundrymen, machinists and technicians work together as a team to make sure Walworth Pressure-Seal Valves will deliver lasting dependability.

If you, like the Walworth Customer, invariably insist on convincing proof of quality, we want you for a customer, too. For full details on the full line of Walworth Pressure-Seal Steel Valves, see your nearby Walworth distributor.

Or write **WALWORTH** *750 Third Avenue, New York 17, N. Y.*

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George Edwards

discusses a matter of bloom or bust

"Familiarity breeds contempt" is an expression we've all heard since we were knee-high to a pipe wrench and it's commonly used to sum up our feelings toward an obnoxious individual. He may be just a back-slapper or a rib-digger or, more often, a guy who can't seem to keep his nose out of our private affairs. By and large we avoid this type whenever possible. Having to come into daily contact with him in our workaday world can and often does make the best of us blow a gasket.

But this "familiarity breeds contempt" theme can involve more than personalities. It can have results ranging from a hair-raising scare to a tragedy. For example, a boiler operator gets too "familiar" with his job. He's an expert, he thinks; *he* doesn't have to bother with a burner torch—so he tries to light off from hot brickwork. We all know how often he lights off more than he bargained for.

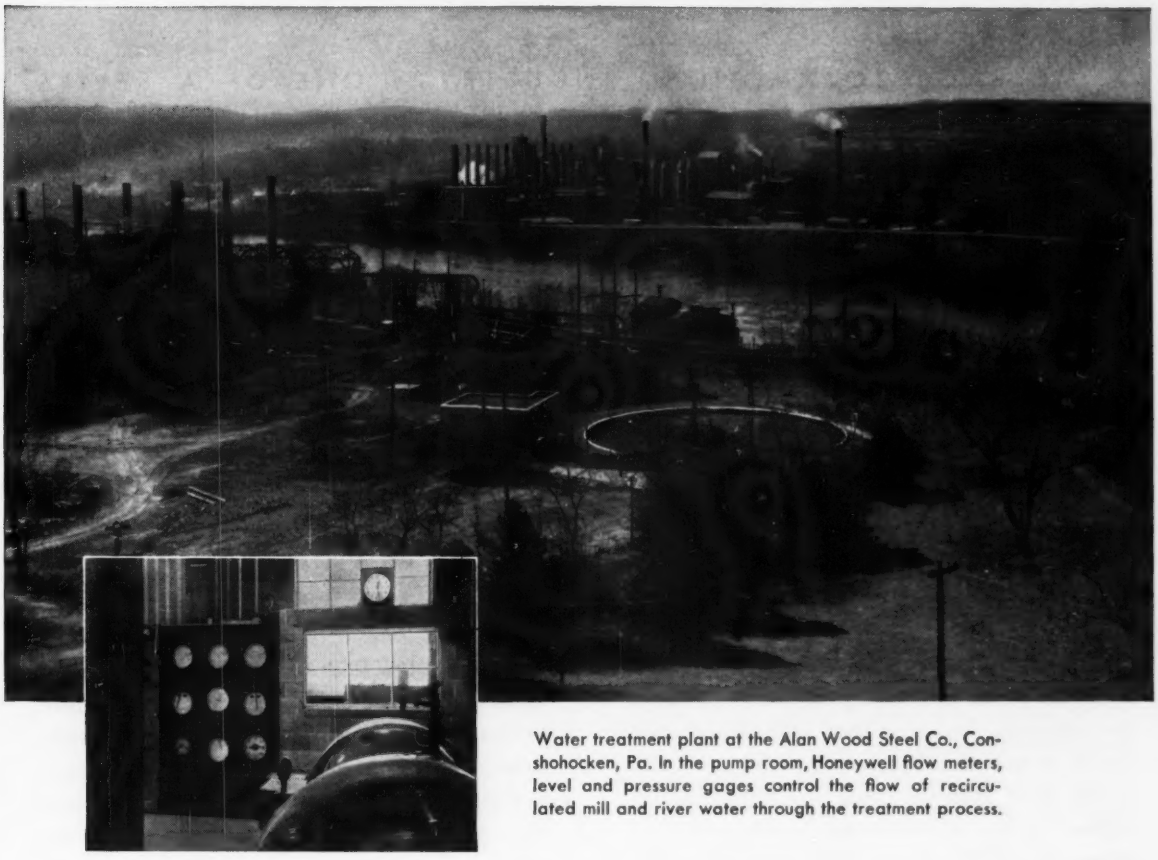
Or take the guy who gets too "familiar" with machinery he uses or operates. He ignores guards, wears his safety glasses in his shirt pocket and otherwise by-passes devices whose sole purpose is to protect *him*. Too often, reaction to this "contempt" is swift and usually painful. Unlike a human being, mechanical equipment understands only one definition of the word tolerance.

But there are two sides to the coin. We can say with conviction based on experience that familiarity breeds *confidence*, too. Here, of course, we're using "familiarity" in a far different sense than before. And, relatively speaking, it affects our lives more than we realize. In fact, we pay a tremendous compliment to many items we have or benefit from merely by taking them for granted. This stems from the simple fact that long familiarity has bred our complete confidence.

Suppose you couldn't casually flip a switch and *know* that the juice would be there to flood your home, office or plant with light? Suppose you had to wonder whether you'd be *lucky* enough to get current when you needed it? Sounds silly, doesn't it? Think of your light switch, back through all the wiring, transformers, switchgear, the generators and their turbine or engine drives, the boilers and their related equipment. You'll find they represent the common denominator—confidence. People responsible for the equipment's performance selected it because they were *familiar* with it, thus confident it would do the job. From their confidence, indirectly, stems yours as you flip the switch and instinctively know you'll have current at your demand.

You can think of plenty of examples other than your electrical supply, and it all adds up to the same thing. Familiarity with *results* has bred complete confidence in the person or product involved.

How do people learn of your good qualities, or of a product you have to offer? How do they make the acquaintance that leads to familiarity that breeds confidence? I don't think it's a question of not hiding your light under a bushel, but of making sure you put it in the right window.



Water treatment plant at the Alan Wood Steel Co., Conshohocken, Pa. In the pump room, Honeywell flow meters, level and pressure gages control the flow of recirculated mill and river water through the treatment process.

Industrial Water and Waste Treating...reduced to routine supervision by Honeywell instrumentation

At the Alan Wood Steel Plant, Honeywell instrumentation was applied to treat waste, as well as to condition incoming river water for mill requirements—a total of 20 million gallons per day. Overall plant efficiency is increased, and maintenance is reduced. By providing a constant supply of uniform water, Honeywell controls effect savings throughout the plant, and permit closer control of process temperatures and pressures. Controlled waste discharge contributes to good community relations.

Honeywell instrumentation is now serving in hundreds of industrial and municipal water treatment and waste discharge processes. In every case, it offers closer control and higher efficiency of water treatment. Regardless of your specific need, Honeywell instrumentation can save you money, both directly and in end benefits. Contact your nearby Honeywell field engineer for help with your water or waste treatment problems . . . he's as near as your phone.

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Depreciation Reform—

Why Industry Needs A Modern Tax Policy

A shockingly large proportion of our industrial plant and equipment is obsolete. As indicated by an earlier editorial in this series, over $95 billion would have to be spent —and spent soon—to bring our industrial facilities up to the best modern standards. Yet plans for 1959 call for little more than $30 billion of actual spending—barely enough to make a start on this backlog of modernization.

At the heart of the problem of obsolescence is a federal tax policy that discourages business from replacing inefficient facilities. It is the purpose of this editorial to spell out a tax reform Congress can make this year—with little cost in terms of tax revenue—that would go a long way toward removing the barrier to modernization of plant and equipment. This reform is a more realistic system of tax deductions for depreciation and obsolescence of productive facilities.

A Barrier to Modernization

Industry abounds with examples of old and obsolete facilities—despite large expenditures made in the past few years. Two-thirds of our metalworking equipment is over ten years old. Over half the capacity of our chemical process industries was installed before December 1950. Only a minor fraction of our railroad freight moves in new freight cars or the new push-button freight yards.

The tax law bears a large part of the responsibility for this lag in modernization because of its important influence on business investment in plant and equipment. For many years the tax law has permitted as a deduction from income "a reasonable allowance" for wear and tear and obsolescence of productive facilities. These annual deductions affect business investment in several ways.

- They are the way a company recovers its investment in plant and equipment.
- They determine in large measure, the amounts of money that are spent each year to replace and modernize facilities.
- Furthermore, the schedule for depreciation often determines **when** a specific machine or building is actually replaced.

The law requires that depreciation deductions be spread over the "useful life" of a building or machine. But the periods of useful life for tax purposes today still depend heavily upon tables drawn up by the Treasury almost 20 years ago. These tables reflect the replacement practices of depression years. Also, they were compiled at a time when the pace of technological progress in industry was much slower than it is now. **For nearly all types of equipment the indicated period of useful life is longer —sometimes much longer—than most experts consider realistic at today's rate of technological advance.**

The result of these outmoded depreciation schedules is that the recovery of investment is dragged out, and the replacement of obsolete equipment is delayed.

In The Right Direction

Congress should establish, by law, the right to use shorter depreciation periods on productive equipment. It should do so in a way that would free industry from obsolete concepts of the rate of technological change and would provide incentives to install new equipment and produce new products.

The tax reform act of 1954 made some progress in this direction—but not enough. It introduced new methods for calculating depreciation —the declining balance and the sum-of-the-years' digits—which enable a business to recover most of the investment in a new facility in the early years of its useful life. However, these new methods do not accomplish their desired purpose when the supposed "useful life" is still an unrealistically long period of years.

Industry is by no means free from blame for the failure to bring depreciation policy into line with the needs of a modern, growing economy. According to Joel Barlow, president of the Tax Institute, "management has largely ignored the Commissioner's invitation . . . to come into the Internal Revenue Service office and make a case for shorter depreciable lives by establishing technological obsolescence."

The failure of many companies to see their own interest in more realistic depreciation not only holds them back from modernizing their own facilities but also lends support to the Treasury in its continued adherence to an outdated policy.

A Suggestion For Reform

An excellent model for reform of the depreciation policy in our tax law is the system used successfully in Canada for a decade. In Canada, all productive equipment may be depreciated at relatively fast rates assigned to each of 14 broad categories. The Canadian system permits depreciation up to twice as fast as the antiquated tables of useful lives now followed in the U. S. It also gives the individual business far greater flexibility in determining depreciation schedules that fit its own needs and experience.

For example, in the category or "bracket" covering general machinery a taxpayer in Canada may depreciate up to 20% of the machine's value annually, on a declining balance basis. In the U. S. the fastest rate at which many types of machinery can be depreciated is only 10%. In other categories, from tools and dies to buildings and pipelines, the Canadian system also allows faster depreciation and provides greater incentive to invest in new facilities.

The cost of this reform in terms of lower tax revenue would be small—probably less than $500 million in the first year. And even this would merely be postponed, not permanently lost. Indeed, there is a very good prospect that tax revenue would not suffer at all. The increase in spending for new plant and equipment resulting from this tax reform would mean an increase in wages and profits—and therefore in taxes—in industries that produce machinery and other capital goods.

A realistic tax policy on depreciation would provide a badly needed incentive for industry to replace obsolete and inefficient facilities with up-to-date plants and equipment. It would step up our rate of technical advance and economic progress. And it would put U. S. industry in better shape to meet the growing competition from other countries that have grasped the advantages of fully modern technology.

This message was prepared by the McGraw-Hill Department of Economics as part of our company-wide effort to report on opportunities for modernization in industry. Permission is freely extended to newspapers, groups or individuals to quote or reprint all or part of the text.

Donald C. McGraw

PRESIDENT

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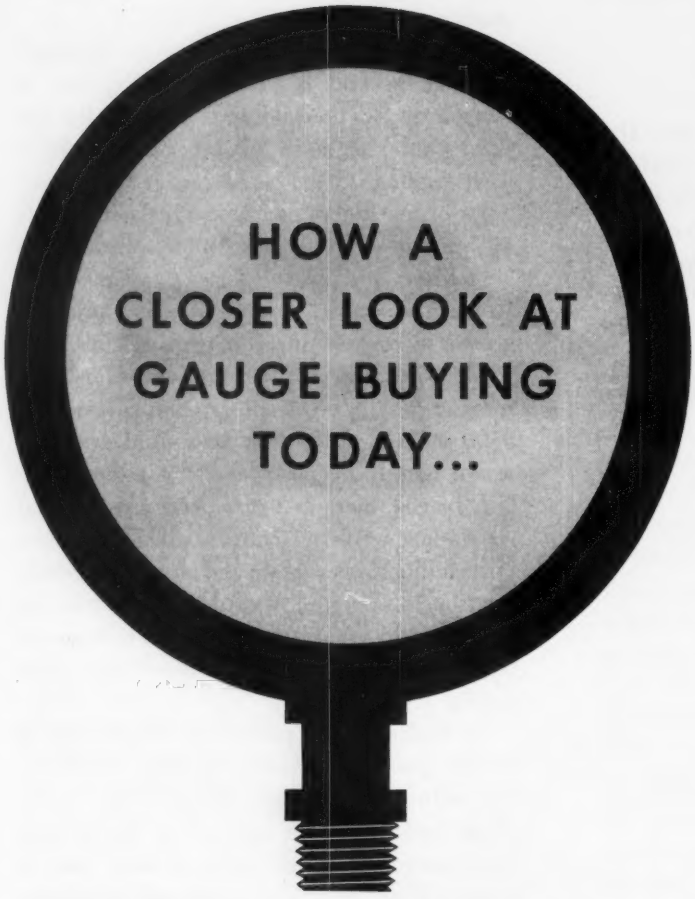

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Been taking gauges pretty much for granted? As to the price you pay, accuracy you buy, performance you get . . . gauges you use and their maintenance costs? Maybe it's time for a closer look at the United States Gauge line and how it can streamline buying. USG features the most comprehensive line of indicating dial pressure gauges you can draw on . . . in range of case styles, materials and sizes, in pressure ranges and in price . . . up to the finest gauges money can buy. The *completeness* of the USG line can help you avoid over-buying, under-buying, help you get exactly the gauge performance you pay for . . . from one source! As shown at right, exclusive USG design features even help cut maintenance costs. Check your USG distributor for your next gauge requirement. See the Yellow Pages, or write for catalogs and name of your nearest USG distributor, today.

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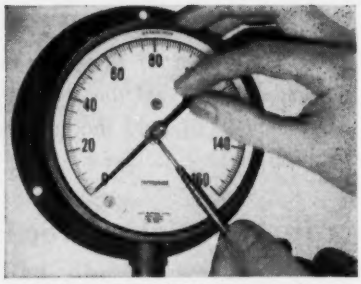
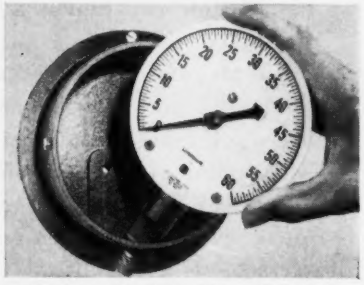
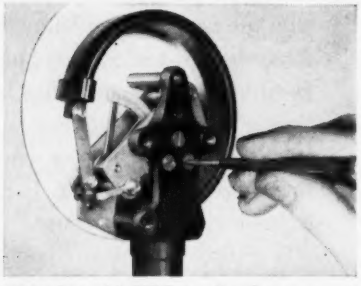


NOTE that with a USG Supergauge®, complete recalibrations can be made faster than with any other process gauge. For example: "zero shift" adjustments are made from the front with gauge in operating position, and without removing pointer from the shaft.



NOTE that with USG Mono-Unit design, internals are in one assembly which lifts out intact. Legend on dial gives full information for instant identification of model number and materials in components. More maintenance minutes saved!



NOTE that with USG Arc-Loc® movement, corrections for "scale shape" (linearity) errors and "range" adjustments are both made from the rear; no need to remove pointer and dial. USG's unique locking method eliminates creep during locking, saves more time! USG Supergauges meet A.S.A. standards for Grade AA Test Gauges, including accuracy to ½ of 1%. *Write for Catalog 1819.*

SAVINGS IN USG A-LINE, TOO!
Premium gauge construction at savings up to 40% of premium prices! Major economies in pressure measurement where you may now be buying more gauge than you need! Meets A.S.A. Grade A standards, including accuracy of 1%. Wide choice of options. Has Supergauge Mono-Unit design — cuts recalibration time. *Write for Catalog 305.*

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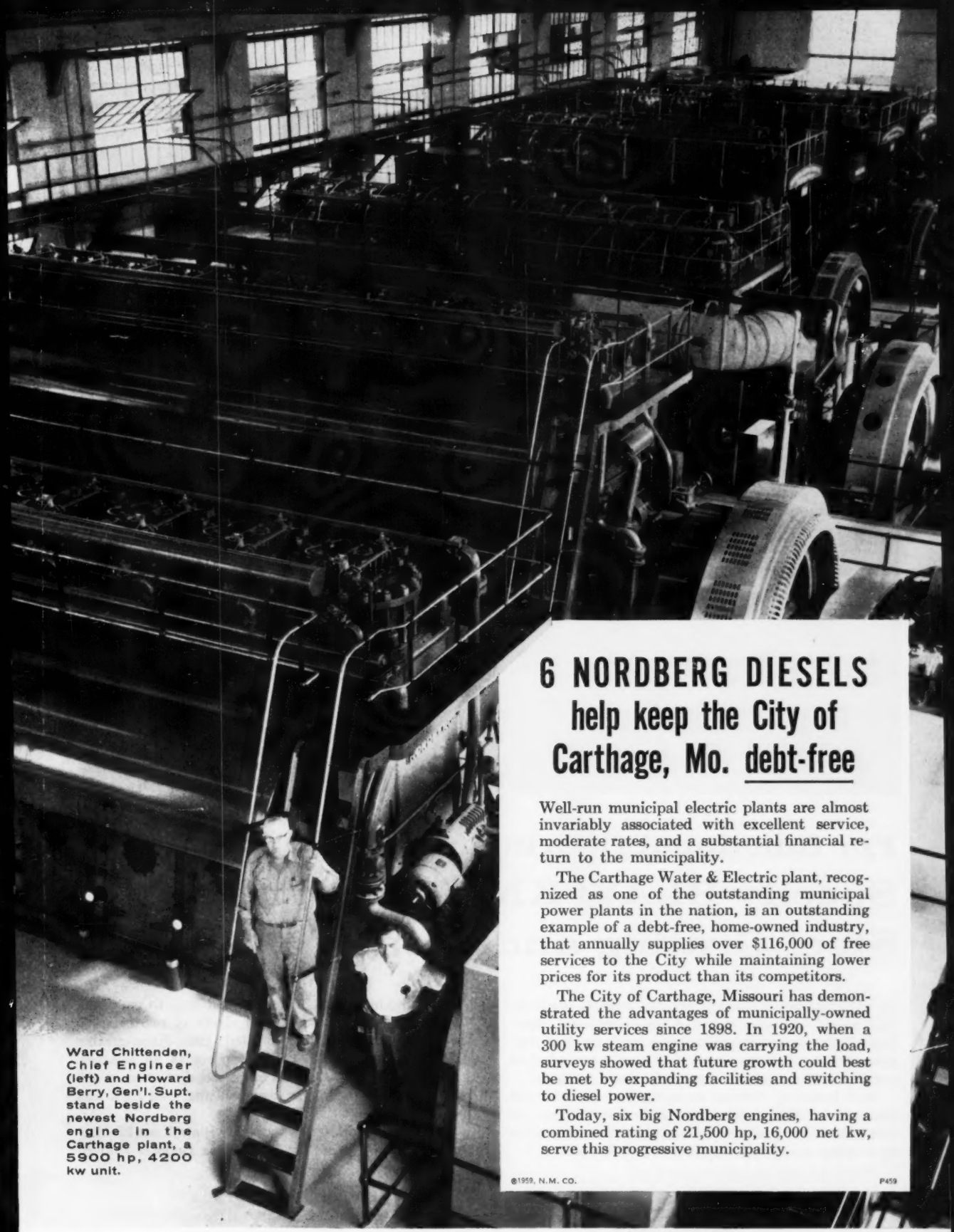

Ward Chittenden, Chief Engineer (left) and Howard Berry, Gen'l. Supt. stand beside the newest Nordberg engine in the Carthage plant, a 5900 hp, 4200 kw unit.

6 NORDBERG DIESELS help keep the City of Carthage, Mo. debt-free

Well-run municipal electric plants are almost invariably associated with excellent service, moderate rates, and a substantial financial return to the municipality.

The Carthage Water & Electric plant, recognized as one of the outstanding municipal power plants in the nation, is an outstanding example of a debt-free, home-owned industry, that annually supplies over $116,000 of free services to the City while maintaining lower prices for its product than its competitors.

The City of Carthage, Missouri has demonstrated the advantages of municipally-owned utility services since 1898. In 1920, when a 300 kw steam engine was carrying the load, surveys showed that future growth could best be met by expanding facilities and switching to diesel power.

Today, six big Nordberg engines, having a combined rating of 21,500 hp, 16,000 net kw, serve this progressive municipality.

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P459

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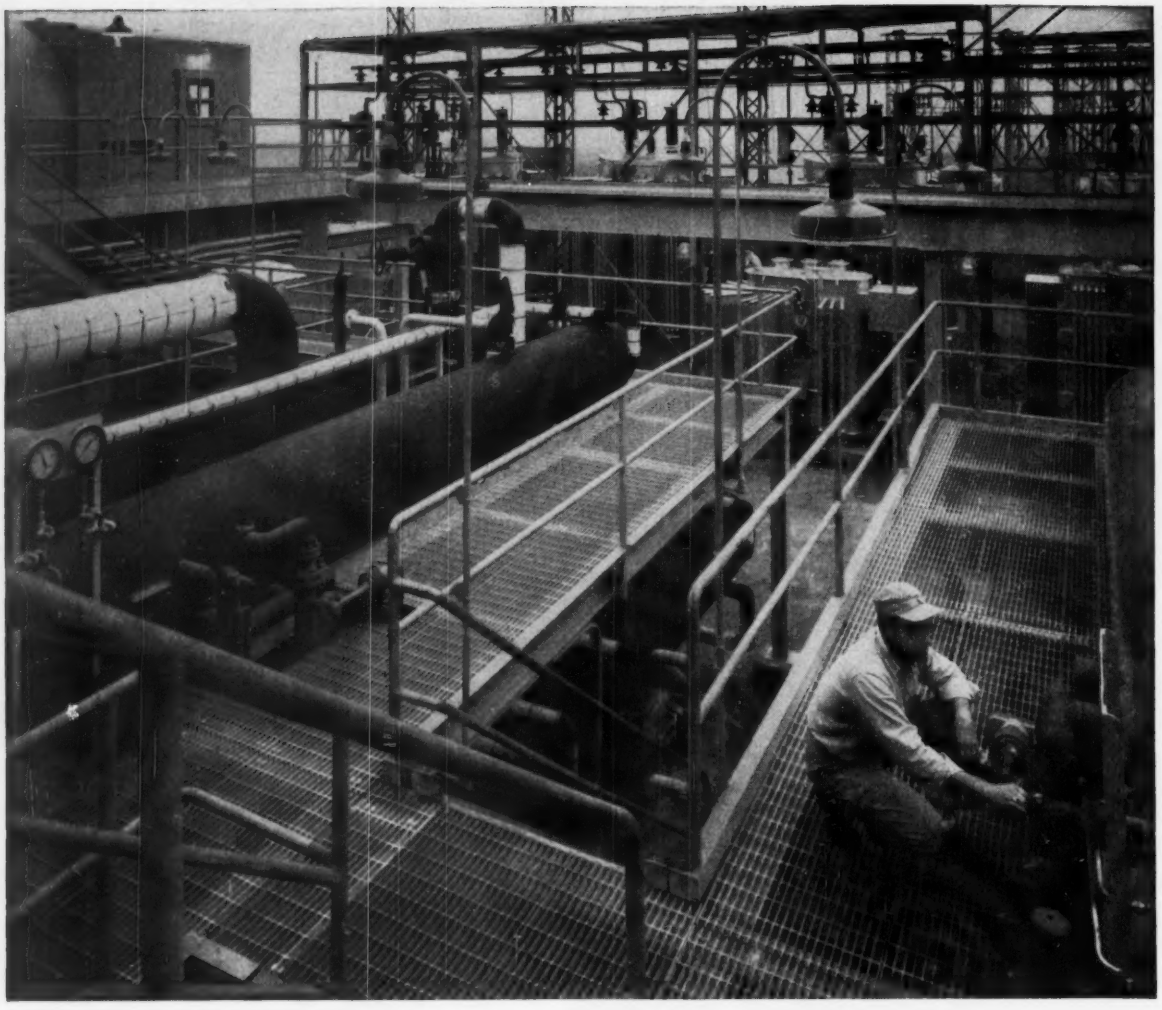

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To be functional, a flooring material must be easily installed, and as easily removed for alterations. Blaw-Knox Electroforged Steel Grating is made in rigid, one-piece sections that can be cut to fit neatly around pipes and beams and altered to meet new space demands.

Once installed, flooring must support its load and resist wear. Blaw-Knox grating is *Electroforged* for strength. Bearing bars are not weakened in fabrication by slotting . . . no bolts or rivets to work loose.

Flooring must be safe to use, and easy to maintain. With its twisted crossbar, and choice of two types of bearing bars (square and serrated) Blaw-Knox grating is the safest possible walking surface in all weather. Grating does not collect oil or grease, dirt or snow. All surfaces are exposed for easy painting, and light and air can pass right through.

For information on how to specify Blaw-Knox Electroforged Grating, write for Blaw-Knox Bulletin 2527-R.

BLAW-KNOX

BLAW-KNOX COMPANY
Blaw-Knox Equipment Division
Dept. Y, Pittsburgh 38, Pennsylvania

For more facts circle 549 on Reader Service card, p 125

BALANCING rotating machinery

By STEVE ELONKA
Associate Editor

EXCESSIVE vibration is often the first sign of trouble in today's high-speed rotating machinery. But if you detect vibration in the early stages, you can often prevent damage.

So measuring vibration, keeping a log and checking against a norm or maximum tolerance that was established when equipment was new, is not only good practice, but a must. This is especially true for equipment like electric motors or draft fans, where blade erosion gradually brings about a state of unbalance. Precision balancing of rebuilt equipment often gives you good-as-new performance.

How precise must equipment be balanced? There is no flat general answer. At high speed, for example, weight of a pencil mark on the rim of a tiny rotor can throw it so far out of balance that it will vibrate violently. Today's balancing machines tell you where to change weight and the amount. They do most of your figuring, even the work.

There are many kinds of portable detecting and balancing units available for field work. No preventive maintenance program is complete without them. Used at scheduled periods they'll prevent metal fatigue, worn bearings, costly outage. You'll also detect many ills caused by faults other than unbalance. Remember that vibration represents energy diverted from a useful purpose to a destructive end.

The pages that follow outline a practical approach to a subject of growing importance. Although it is the responsibility of the equipment manufacturer to deliver to you a piece of finely balanced equipment, it is your job to see that balance is maintained for a full machine life.

a **Power**
special report • June 1959

1 UNBALANCE— what causes it, how it's measured

Nonsymmetrical weight distribution is basic cause of unbalance

Knowledge of what causes unbalance is needed to understand why rotating machinery vibrates and how vibration can be stopped. So before tackling the more complex subject of vibration analysis, let's look at a few common causes of unbalance and learn how they can be corrected.

The most carefully finished rotating body will vibrate when spinning at high speeds, even though it has been carefully balanced on a modern balancing machine. One way to cut the high cost of machining and improve the quality of the product is to (1) machine only the working surfaces and (2) balance the body after machining. Automobile manufacturers are already doing this on belt sheaves, crankshafts, fluid drives and other rotating parts.

Nonsymmetry in cast parts ranks as one of the most common causes of unbalance. Unmachined surfaces of most castings and forgings, such as the cast impeller in Fig. 1, can't be made absolutely uniform with their rotating axes. Among the many reasons are core shifts during casting which cause the center of gravity of the rotational axis to be out of true with its established bore.

In manufacturing parts, such as the armature of an electric motor or generator, Fig. 3, it's often impossible to avoid nonsymmetry. Some universal motor armatures have one coil that is farther from the rotational axis than the coil opposite it. Thus the armature, small as it is, is thrown out of balance. Too, nonsymmetry crops up in these parts because lacquer used to impregnate coil windings can't be applied uniformly. Makers of many other rotating machine parts are confronted with similar problems of unbalance.

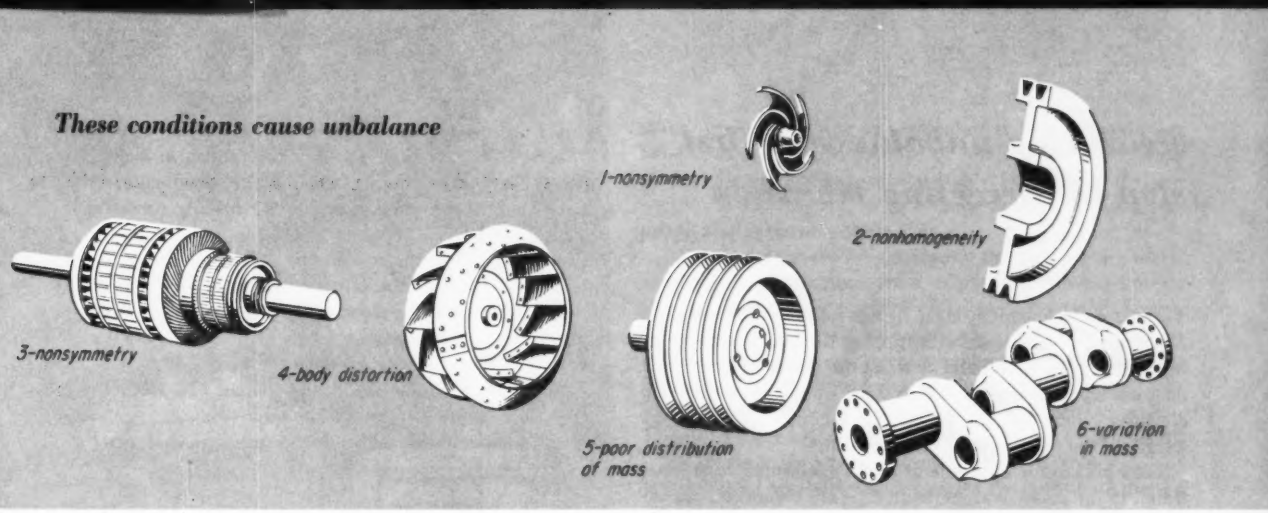
Nonhomogeneity is a characteristic of all materials, regardless of how they are produced. For instance, the blowhole in the completely machined pulley, Fig. 2, will throw the pulley out of balance. But it doesn't take anything as obvious as a blowhole to unbalance a completely machined component, whether it's cast, rolled, forged, formed, extruded or made by other means. Slag inclusions and variations in the crystalline structure of the finest steels may not be prevented. And porosity or other imperfections in castings can be spotted only by X-ray, magnetic-particle or microscopic examinations. But these imperfections *are* there, pointing up fact that no material is perfectly homogeneous.

Distortion in the rotating part at operating speed is a third cause of unbalance. Thus the fan blades, Fig. 4, may expand or distort while running. Because of initial stresses and variations in material thickness, this distortion is nonsymmetrical. It causes one blade to move out farther radially from the rotational axis than the blade opposite it. This displaces the center of gravity of the fan, causing vibration and noise. Result: metal fatigue, worn bearings and ultimate fan failure.

Poor distribution of mass in a completely machined component is a cause of unbalance that is often overlooked. Example: In the sheave, Fig. 5, usual tolerance allowed for runout of the outside diameter in relation to its bore is about 0.002 in. This is enough to make one side of the sheave heavier than the other. Again, the center of gravity of the piece is forced out of the rotational axis as determined by its bore. So remember, unbalance is caused by tolerances that permit eccentricity or that don't square up machined surfaces with their rotational axes. Even when a bore and shaft are concentric the difference in size may allow a set screw to push the part far enough off center to result in conditions of unbalance.

Variation in mass distribution also unbalances rotating assemblies. If the flywheel, Fig. 6, has a clearance in its bore of a few thousandths of an inch and is keyed to the shaft, the unit will be out of balance even though both pieces were individually balanced before assembly. Too, a loose-fitting flywheel may shift radially, pushing the center of gravity of the flywheel off the rotational axis of the crankshaft. The entire assembly will be unbalanced when it rotates on its crankshaft bearings.

Eccentricity, even though held to a few ten-thousandths of an inch, is also a mark of unbalance in rotating equipment. A common example is the inner race of a ball bearing. No ball-bearing manufacturer will guarantee the bore of the inner race (the part pressed onto the shaft) and the groove on its circumference for perfect concentricity. Here, eccentricity forces the rotor supported by the inner race to revolve about an axis other than that for which it was originally balanced. This is true if the part was last balanced on the diameter of the shaft rather than on its bearings. Every time you renew ball bearings on your



equipment, you run the risk of throwing the rotor out of balance.

Eccentricity of rotor journals can lead to vibration, even though rotor is otherwise in balance. Depending on machine, eccentric journals may induce mechanical, electrical or windage forces at rotational frequency.

Rotor assembly can result in a knotty balance problem. For example, if several rotor parts are balanced before assembly, unbalance or eccentricity often result from inaccuracies of the assembly tolerances. But, if the complete rotor is balanced before assembly, the balance can easily be destroyed by replacing a shaft sheave in a slightly different position. And if the armature and sheave are balanced separately, the unbalance tolerances in each part can become cumulative when they're assembled. Answer to this problem lies in balancing the unit only under assembled conditions.

Bent shafts, of course, mean unbalance. Bending is commonly caused by pressing a rotor onto a previously finished ground shaft without due care. Shafts on large steam turbines will bend from uneven heating during startup. Too, shafts are bent in many ways during manufacture; most common resulting from stresses locked up in shaft from grinding, heat treating, other manufacturing operations.

Main cause of unbalance in larger rotating parts, such as the rotor of a steam turbine-generator, is an unequal weight distribution in the spindles or shafts. Usually a number of factors contribute to this condition, including machining tolerances, assembly procedures, nonuniform materials and other imperfections in the overall assembly.

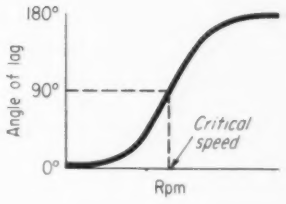
Shaft flexing. In machinery having a nonsymmetrical shaft or body there are various deflections for different shaft or rotor positions. This variation of deflections is a function of angularity and at high speed causes vibration of a different frequency. Correction of this vibration cannot be done by mass addition—if possible, it's accomplished by making moments of inertia equal by slotting or other means. It's a condition not uncommon to electric rotors of large generators.

Shifting of parts that are either pressed onto a shaft or held by other methods can cause a condition similar to flexing of nonsymmetrical shafts. To keep a shaft straight the forces exerted on the shaft by added parts must be kept uniform *around* the shaft. Deformation of this kind can come from an axial shift of a coil support ring. Then, pressing the end disk onto the shaft may cause local flexing. Spindle rings shrunk onto a slender shaft with too little axial clearance will also bring on trouble. Here, forces transmitted from one blade ring to the next at operating temperature flex the shaft in the area of the blade rings.

Hydraulic vibrations may crop up from cavitation in pumps, vibrations excited by fluid flows and other conditions. Vibrations on precision machine tools sometimes are traced to the hydraulic system.

Temperature may cause changes in structure which increase vibration by bringing critical speed closer to operating speed. Thus, a machine that's smooth when cold may be rough when hot. These are a few causes.

Principle behind the adding of balance weights



High spot is the point on a rotating body that is thrown outwards by unbalance once each revolution. This point isn't necessarily the heavy side of the body, but it serves as your best guide for placing balance weights. At low speed vibration is in phase with rotary motion. The high spot corresponds to the heavy side, so place balance weights opposite high spot.

As speed increases, vibration starts lagging behind the rotary motion. High spot no longer is the heavy point. This angle, or change in high spot, is called the angle of lag. It falls anywhere between zero and 180 deg, depending on the machine and its speed. As speed increases the high spot shifts and lags the heavy spot. This angle of lag increases until it finally reaches a position directly opposite the heavy spot, as indicated by the above curve.

Curve also shows the relationship between speed and lag. Below critical speed, lag is less than 90 deg; above critical it is more than 90 deg. You must find the high spot with some of the many types of balancing devices described here. Then you can add a trial weight, run the machine and note change caused by the weight.

Measuring unbalance is first step in correcting vibration

To balance a machine, mass in the rotating part must be distributed to eliminate vibration at the supporting bearings. So a body is in balance when the center of gravity of its mass coincides with the axis in which it rotates. We consider center of gravity as the location at which all weight of the rotating part is concentrated.

Let's glance for a minute at the two spinning tops illustrated in the panel at right. Both tops are balanced because the mass centers of their bodies coincide with their rotating axes. But note that the second top has a weight added to one side. In this case, since the rotational axis isn't restricted (unlike a shaft which is held between bearings), the spinning top is balanced by centrifugal force; its rotational axis is in the center of its mass.

Measuring unbalance. Before vibration can be corrected we must know how much the rotating part is out of balance. Unbalance in a rotating body is measured in ounce-inch (oz-in.), gram-centimeters (g-cm) or, more recently, gram-inch (g-in.). One oz-in. equals 72 g-cm. For purposes of this report we'll use the term oz-in.

Unbalance is a product of weight and displacement. Thus unbalance figured in oz-in. is the product of the weight, in ounces, times the distance, in inches, that the weight is from the center of rotation. Here's how the unit oz-in. is applied:

Centrifugal force exerted on the restraining bearings of an unbalanced rotor is proportional to (1) the weight of the rotor and (2) the distance its mass center is displaced from the rotational axis. Thus a rotor weighing 62.5 lb (1000 oz) with its mass center displaced 0.001 in. from the rotational axis is one oz-in. out of balance.

Bottom drawing in panel at right shows a balanced arrangement using different size weights, but the same number of oz-in. on each side of the fulcrum point. The 8-oz. weight on the left is 2 in. from the fulcrum point or center of balance; giving us 8 oz. times 2 in., or 16 oz-in. of unbalance. This is counterbalanced by a 2-oz weight, 8 in. to the right of the fulcrum point; or 2 oz times 8 in., also giving us 16 oz-in. of unbalance.

Remember, centrifugal force due to unbalance produces vibration. And centrifugal force increases as the square of the rotational speed. So by doubling rotational speed you increase centrifugal force fourfold; by tripling rotational speed you increase centrifugal force ninefold. It's easy to see, then, why unbalance plays such an important role in modern high-speed machinery. Our predecessors in the power field who worked with relatively slow, cumbersome machines were not faced with many of the problems of unbalance that are with us today.

Curves in the graph, at right, plot four different values of unbalance. They clearly indicate the rapid increase in unbalance force brought about by increase in rotational speed of the part being balanced.

How much unbalance? To determine the number of pounds of centrifugal force developed by a definite number of oz-in. of unbalance, we can use formula: $F = KWRN^2$ when F is centrifugal force, lb; K is the constant 17.75×10^{-7}; W is weight, oz; R is the radius, in inches, at which the weight is acting; and N is the speed, rpm.

Let's look at a typical example for finding centrifugal force in pounds:

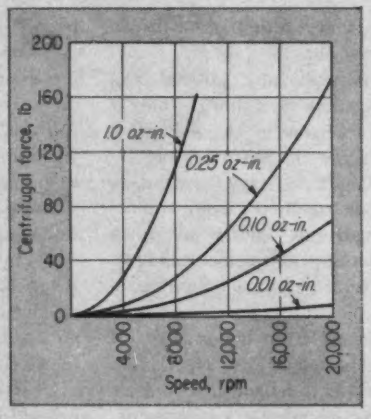
Given: A gas turbine running at 12,000 rpm has a 1/4-oz unbalance, 6 in. from the center of balance. *Find:* Amount of unbalance (centrifugal force, lb) that causes the turbine to vibrate:

$F = 17.75 \times 10^{-7}$ times 0.25 times 6 times $12{,}000^2$

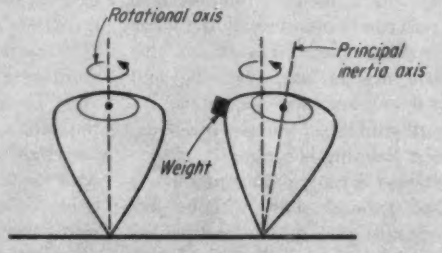
$F = 17.75 \times 10^{-7}$ times 0.25 times 6 times 144,000,000

$F = 383.4$ pounds of unbalance

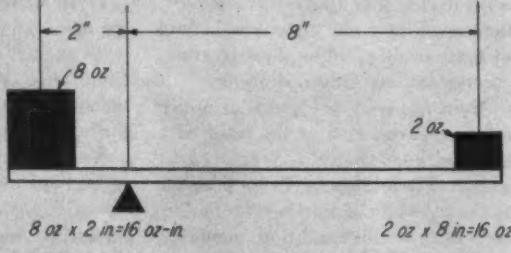
Now, let's learn about the various kinds of unbalance.



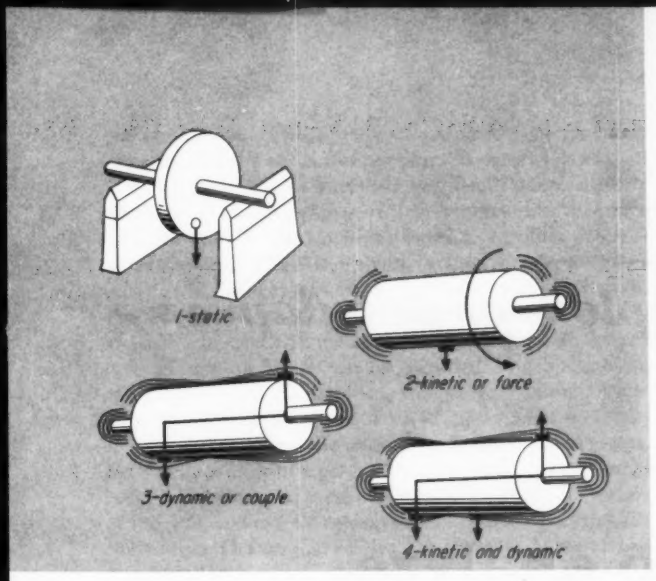
CENTRIFUGAL FORCE increases rapidly with speed, as curves show. Unbalance values used are common in practice.



BOTH TOPS are balanced as they spin because the mass center of their bodies coincide with their rotational axes



UNIT for measuring unbalance is the oz-in. This is product of 1 oz of weight placed at a radius 1 in. from the center



Here are major types of unbalance

Unbalance falls into three general classifications: *static, kinetic or force, dynamic or couple*, and a combination of kinetic and dynamic.

Static unbalance involves only gravity or weight force. For example, let's assume that a rotor is perfectly balanced and, therefore, won't vibrate regardless of the rotational speed. If you place it on frictionless rollers or knife edges, Fig. 1, above, and add a weight at the center of gravity line, gravitational force will cause the weighted portion to roll to the bottom of the rotor. This condition is called *static unbalance*. If the rotor doesn't rotate, you can balance it on knife edges as shown in Fig. 1.

Kinetic or force unbalance is actually static unbalance, but it occurs when the rotor spins. The unbalance weight sets up a centrifugal force that causes deflection of the rotor in the same direction as the unbalance force. Result: distortion in the form of bending or flexing which increases decentering and, in turn, increases centrifugal force. (These effects don't show up in static-balancing procedures.)

Centrifugal force increases proportionately as the square of the rotor speed. If the rotor is at all flexible, it will deflect or bend in the direction of the original static unbalance weight, increasing distortion. Deflection of the rotor results in still greater centrifugal force which, in turn, means even more distortion which will complicate the problem.

Both static and kinetic unbalance are treated alike in narrow, relatively rigid rotors. But with longer, more flexible rotors, kinetic unbalance alone governs correction procedures.

Dynamic or couple unbalance. Dynamic unbalance is often referred to as any type of rotating unbalance. Technically speaking, however, dynamic unbalance is usually considered as a "couple" or twist caused by two equal forces in two separate planes, 180 degrees opposite each other. Important thing to remember is that dynamic unbalance is caused by presence of two weights in separate planes, diametrically opposite each other. Effect of these weights is to make the rotor rock or twist on an axis perpendicular to the axis of rotation.

Suppose we place a weighted rotor on frictionless rollers, as in Fig. 3, above. Since each weight is 180 degrees opposite each other, no one point rolls to the bottom of the rotor. Thus, the rotor is balanced statically. But if the rotor revolves at a fair speed, each weight creates a centrifugal force. And, since the weights are in separate planes, these forces cause a rocking motion that tends to twist the rotor. This type of unbalance is called *pure dynamic unbalance*.

To observe this action, place a pencil on a table and push it away from you with one finger. At the same time place a finger of your other hand in another plane on the pencil and push toward you. The pencil will rotate end for end. In a rotating rotor this end-for-end action is restricted by the bearings that hold the rotor in one plane. However the tendency to turn end for end is still there. It's this twist force that causes the rotor to vibrate.

Remember: Pure dynamic unbalance rarely occurs in rotors. To illustrate, let's place a weight on a perfectly balanced rotor, to one side of the center of gravity line. Immediately we have static unbalance; the weight causes the rotor to turn until the weight is at the bottom of the rotor. Now let's turn the rotor at a fair speed. The unbalance will cause a centrifugal force, resulting in a twisting action as the rotor tries to spin about its center of gravity. Extent of this twist, or the attempt to form a couple, is the amount of dynamic unbalance in the rotor.

Combination of kinetic and dynamic (force and couple) unbalance is shown in Fig. 4. In curing an unbalanced part, some balancing machines treat kinetic and dynamic forces separately; others combine them into a single correction in each of two correction planes.

Advantage of separating the kinetic from dynamic unbalance in job type balancing is that the operator can make his corrections in any plane he desires. If, after determining the angle of unbalance, the operator finds he can make his corrections easier in a plane other than his original choice, he can quickly make the change. Separating kinetic from dynamic unbalance also is helpful when balancing rotors that may deflect at operating speed.

Much can also be said in favor of balancing machines that combine kinetic and dynamic unbalance into a single indication of angle and weight in each of two correction planes. Widest application for these machines is on production lines where many similar parts are to be balanced. Here, the flow of product along conveyor lines is important and time is a big factor. Time is not as major a consideration when a given part is removed from a machine for balancing, such as for an annual overhaul. Incidentally, more and more makers are balancing all rotating machine parts.

EDITOR'S NOTE: Three terms are used to denote the idea of a single centrifugal force in one plane. For this report we will use the word *force*, recognizing that *static* and *kinetic* also have the same meaning.

Too, the term *unbalance* is used throughout this report instead of *imbalance*. One week prior to publication of this report, the ASA Committee S-2-W-36 agreed on use of the term *unbalance* as the industry standard.

2 VIBRATION— the symptom of unbalance

Next, here's how to analyze and record vibration

Today, there are many instruments on the market for measuring vibration. Some visually indicate amplitude of vibration only; others provide an oscillographic record of vibration. An example of the latter type is shown in photo, facing page. This vibrograph has a sapphire-pointed stylus that scratches a permanent record of vibrations on a 1-in.-wide waxed-paper chart moving at 1½ in. per second. By filing these charts and referring to them from time to time you can keep a close check on the vibration history of a particular machine. Degree of vibrations can be magnified to 40:1, 20:1, 10:1 or 5:1, as desired. A probe can be attached to the meter for taking readings directly on the shaft—the ideal place to measure vibration. But if you can't get to the shaft, you can make an accurate reading by holding the prong of the stylus against a bearing (see photo).

To grasp the fundamentals of analyzing and measuring vibration, you must understand the following terms:

Amplitude is the extent of vibration in a part. Full amplitude, measured from peak to peak in thousandths of an inch (mils), helps you to evaluate a machine's condition, see sketch, facing page. *Half amplitude* is used to calculate vibration energy. It is the distance a rotating body moves from its neutral position.

Frequency of vibration is the number of complete cycles per second (cps) or cycles per minute (cpm), see sketch. Cycles per minute is generally used because of its relationship to revolutions per minute (rpm).

Steady-state condition exists when the same vibration cycle repeats itself continuously. Example: unbalance in a part rotating at a constant speed.

Transient is an interruption of the vibration pattern over a short period. For example, in Fig. 1 on facing page, the temporary peak was caused by a shock.

Sine wave is vibration produced by a single frequency, such as vibration in a motor having simple unbalance. If another frequency is superimposed, the vibration is no longer a true sine wave.

Beat frequency occurs when two vibrations of almost equal frequency are present. Example: two motors mounted on the same base, but running at slightly different speeds. In Fig. 2, the vibration amplitude pulsates rhythmically as the two frequencies come in and out of step. Thus, the closer the frequencies, the slower the beats.

Natural frequency is the frequency at which a body vibrates if it receives a shock. Adding weight to a body results in a lower natural frequency, while making the body stiffer raises the natural frequency.

Resonance occurs when a disturbing force corresponds in frequency with the natural frequency of a machine part, causing an exaggerated vibration amplitude.

Critical speed occurs when a rotating shaft passes through a speed corresponding to its natural frequency, causing the shaft to bow. As critical speed is exceeded the shaft tends to straighten out again. The machine must be designed so shaft doesn't operate at this speed.

Harmonics. A harmonic is a frequency that combines with others to produce a wave that's a distorted sine wave. Even harmonics are the 2nd, 4th, 6th, etc.; odd harmonics are the 3rd, 5th, 7th, etc. Fig. 3 shows a wave form produced by a fundamental frequency plus a 2nd harmonic. It might result from a shaft geared to run at twice the speed of the motor.

Frequency wave. Sketch, facing page, shows how a frequency wave form is generated. Curve *a* is the fundamental frequency, *b* the 2nd harmonic. Adding *a* and *b* gives us Curve *c*. Numbered ordinates are drawn every 45 deg of the 360-deg fundamental cycle. Ordinates are measured and fundamentals added to those of the 2nd harmonic. Resulting ordinate lengths are then plotted at *c*. If they fall above the neutral line, they're plus; below the neutral line, minus. Therefore, at No. 2 where both are plus, resulting curve is high. At No. 6 the 2nd harmonic is plus, fundamental is minus, so resultant is slightly below the neutral line. When only even harmonics are present, each half of the curve is different. In contrast, Fig. 4 shows a fundamental frequency plus a 3rd harmonic. Here, both halves of curve are the same because harmonics are odd.

Gravity, *g* in sketch, accelerates a dropping body 32.2 ft

per sec, or one *g*. So a body vibrating at four *g*'s has a force on it that's equal to four times its own weight.

Amplitude measurements are ideally taken directly on shaft's rotating surfaces. If this is impossible, then take measurements on the machine's bearings or other external structures. Amplitude in a steam turbine may be less than 0.001 in. at the bearings, but 0.003 in. or more at the shaft. The vibrograph, photo, detects vibration amplitude as low as 0.0001 in. and will measure down to 0.0002 in. Amplitude as high as ⅛ in. can be recorded. Fig. 5 shows an amplitude record of 0.004 in., while Fig. 6 shows an amplitude record of 0.0005 in.—both at 3600 cpm.

Bump test shows the natural frequency of a machine. Delivering a blow to a part sets up a train of damped oscillations. Frequency of these oscillations is natural frequency of the part and can be measured. Bump testing a machine shaft while it's stationary gives you its critical speed when running. Reason: natural frequency and critical speed are practically the same.

Fig. 7 was taken on a large rotor between bearings, with prong held against the center of the rotor. A blow with a sledge on a piece of wood held against the rotor set up a train of oscillations. Because eight complete oscillations show in the ½-sec length frequency scale, we know critical speed was 960 cpm.

Fig. 8 shows results of a bump test on a generator shaft. Here, a steel bar was placed against the shaft and given a blow with a hammer. Frequency of the train of oscillations was 4800 cpm.

Fig. 9 is the result of a bump test on a beam having two frequencies at the same time. Widely spaced oscillations show a natural frequency of 450 cpm. A blow also set up oscillations with a natural frequency of 1800 cpm, which seem to be superimposed on the low frequency. In making your analysis, count low and high frequencies separately on the frequency scale.

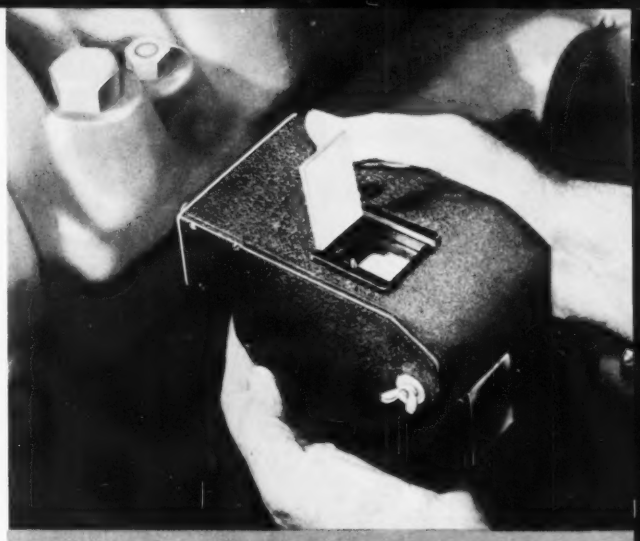
Complex vibrations. Vibration records often depart from the ideal sine wave. Fig. 10 shows a regular wave pattern caused by an unbalanced motor with an amplitude of 0.005 in. There are 29 peaks in ½ sec, showing that motor is running at 3480 rpm. Too, as motor vibrates steadily at high frequency, it's displaced rhythmically at low frequency of about four vibrations per second.

A dip in one side of each wave shows a 2nd harmonic. But this dip doesn't stay in one place; it climbs up and down the wave because it's out of step with rotation. Besides, rate of travel up and down the wave is the same as slow pulsations, showing that cause of each is the same. A 2nd harmonic represents magnetic pulses that occur each 180 deg of the 60-cycle line frequency. Since these are slightly over twice rotational frequency, they cause modulation of the mechanical unbalance wave at about 4 cps. This shows graphically the pulsations often heard in an induction motor, plus the characteristic ac hum.

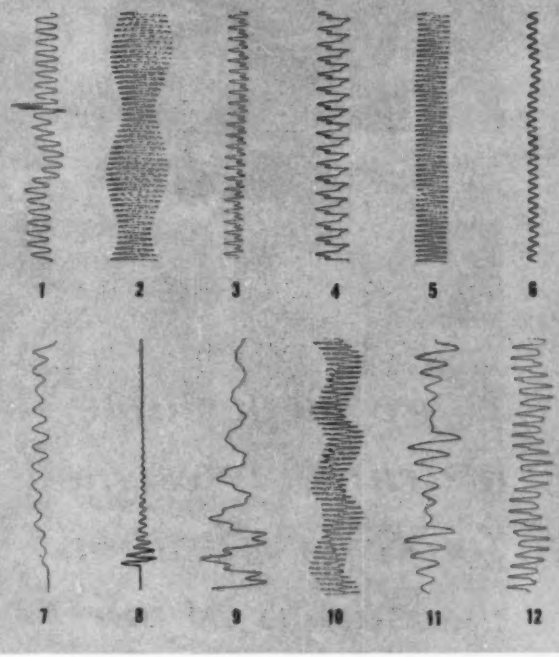
Fig. 11 shows vibration of a belt-joint slap. Chatter from loose members shows up in the vibration records, usually producing saw teeth in the curve.

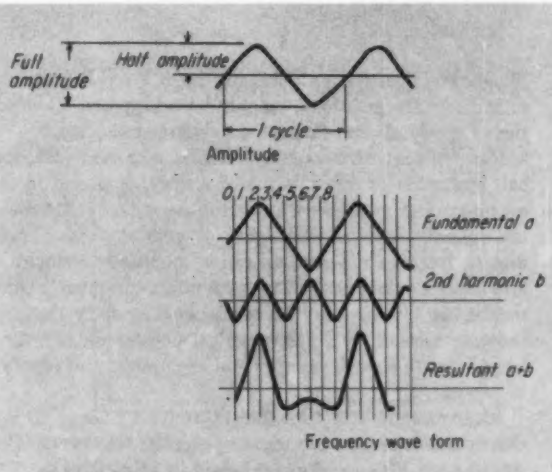
A 2nd harmonic is common; it's shown in Fig. 3 and again in Fig. 12. In Fig. 12, the 2nd harmonic is out of step with the fundamental frequency.

While this information covers only the highlights, it serves to acquaint you with vibration. Now let's see what instruments are available for tracking down vibration.

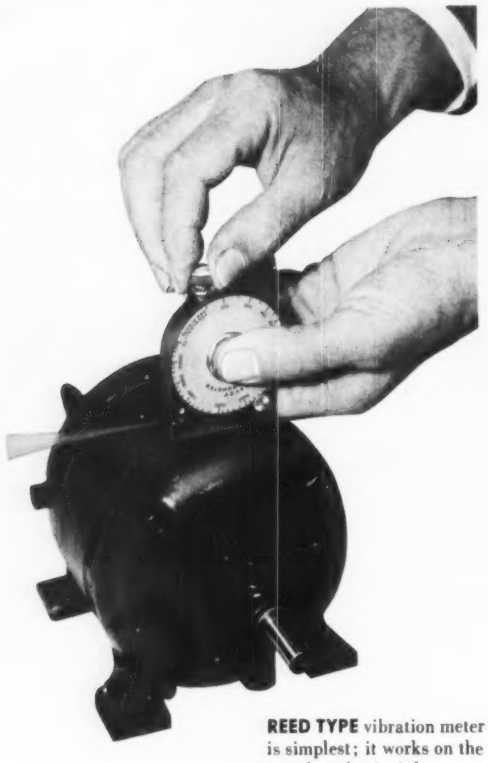


VIBRATION RECORDS, numbered 1 to 12 below, are made with this instrument. To use, hold against shaft, bearings





FREQUENCY WAVE FORM shows how such a wave form is generated, while amplitude indicates amount of vibration. As the sketch shows, amplitude is measured from peak to peak



REED TYPE vibration meter is simplest; it works on the tuned-reed principle

There's a portable instrument designed for every vibration measurement job

Measuring instruments generally have a sensing element to indicate the positions, amplitudes and, possibly, velocities or accelerations of a part at a given point.

Pickups convert mechanical motion into electrical, optical, hydraulic or other forms of energy. Included in this group are meters used with electronic equipment, mechanical methods, optical techniques or combinations. Transducers, too, can measure vibration amplitude, velocity or acceleration when hooked up with other equipment. Other measuring devices may be mechanical systems that (1) indicate motion with a mechanical pointer or (2) use a transducer to absorb energy from one system and supply it to another.

Electromechanical transducers convert energy of mechanical motion into electrical energy, or vice versa, without contact. They also are referred to as *pickups*.

Direct-optical techniques use high-speed streak photography to let you observe motion. Stroboscopic methods in which light pulses of short duration are emitted periodically and used to illuminate an object are applied to both transient and steady-state motions. There are many other methods of measuring vibration. We'll explain only a few having the widest application.

Reed type—one of the simplest vibration meters—measures frequency of machine vibrations and gives comparative readings of vibration amplitudes. It works on the tuned-reed principle. Free end of the reed vibrates at only a single frequency, depending on its length. However, when the reed is acted upon by a vibration corresponding in frequency to its own natural frequency, it develops a vibration amplitude many times above the exciting vibration.

To use, hold the instrument against the vibrating body, photo above. Then feed out steel reed by turning knurled knob. At same time, the dial rotates. As reed nears length where it vibrates at same frequency as the machine, its end will tremor. Adjust reed slightly so it builds up to a maximum amplitude. You can then read vibration on the graduated dial in frequencies per minute. Scale range is 450 to 50,000 cpm.

Mechanical hand vibrometer has a spring upon which the weight of the frame rests. Dial indicator is mounted concentric with the spiral spring. The prong of the dial indicator picks up the oscillations of the spring and ocillates the hand of the dial indicator. This is a very simple instrument, but also very popular.

Lightbeam type vibration indicator, photo, top of facing page, has a plunger for picking up vibrations. When plunger moves, a small mirror oscillates through a sensitive leverage system. Light from a small incandescent lamp is thrown onto the mirror and reflected to a ground-glass scale. Vibrations swing this light beam to and fro, causing it to form a ribbon of light on the scale. Vibration amplitude is indicated by width of this ribbon of light. The scale is graduated in either thousandths of an inch or hundredths of a millimeter. Light source is a self-contained flashlight battery and a miniature lamp.

All-transistor battery-operated vibration meter is shown in lower photo, facing page. Its linear or torsional vibration pickup makes it a completely self-contained monitoring system. No power cords or outlets are needed, making troubleshooting a relatively simple job. Peak-to-peak displacements as small as 0.0005 in. are indicated on the large front-panel meter over a frequency range of 10 to 1000 cycles. An output jack allows you to couple an oscilloscope to this meter for observing vibration wave forms.

Stroboscopes. These instruments use a short burst of light to illuminate a rotating or periodically vibrating body at set time intervals. Intervals are about equal to period of vibration or to some multiple of that period. Rotating body then appears to be stationary or to move slowly. The apparent rate of vibration under these conditions is equal to the differences between the vibration and the flash frequency. Since the flash rate is usually known, you can use this method to find the frequency as well as to observe the details of performance of the moving parts.

Vibrometers, as mentioned before, measure amplitude of vibration; vibrographs make oscillographic records of vibrations. Electrical vibration devices that record amplitude directly on a meter have a pickup, adjustable attenua-

tor, an amplifier and a direct-reading indicating meter.

Frequency meters have a series of cantilever reeds tuned to frequencies separated by small increments. Since they usually have a small frequency range, their greatest value lies in determining rotational speeds of machinery.

High-speed moving pictures are used to make slow-motion studies of the behavior of vibrating equipment. Usually the photographic image is diffracted by a rotating-plane glass prism and travels along with the moving film. Speeds to 15,000 frames per second can be obtained. Moving-film cameras without shutters can be synchronized with stroboscopic light sources to produce several thousand frames per second. Thus, you can see exact position of a shaft during any angle of rotation.

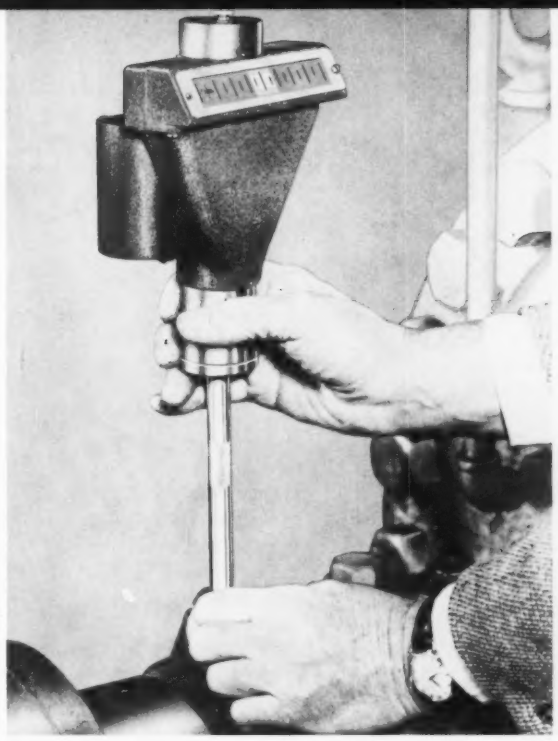
For early detection of relative motion of a shaft you can set up a magnetic-amplifier deflection indicator, either directly on your machine or in a remote location. Unit operates on a 60-cycle 110-volt power source, warns you of trouble by either a visual or audible alarm system.

Wattmeter method of vibration measurement, sketch, lower right, is also widely used. Here, the output of a 2-pole sine-wave generator, coupled to machine's rotor, is fed to the current coil of a wattmeter. Voltage coil of the wattmeter is energized by the output of an electric vibration pickup held against the vibrating body. Indication of the wattmeter is then proportional to the product of the voltage amplitudes of equal frequencies across its two coils, multiplied by the cosine of the angle between them. Thus with a given pickup voltage you can make the meter indicate either zero or a maximum by rotating the stator of the sine-wave alternator to positions where the two voltages on the meter are either out or in phase, respectively. For zero reading adjust the stator position accurately. Angular position of the stator for zero reading is an indication of the phase angle of the voltage pickup. Since this voltage bears a fixed relationship to the vibratory motion, the stator's angular position is the phase angle of the vibratory motion. By shifting generator winding 90 degrees from its zero position you get a maximum deflection on the wattmeter. If alternator current amplitude is held constant, this deflection indicates the amplitude of vibration that is being measured.

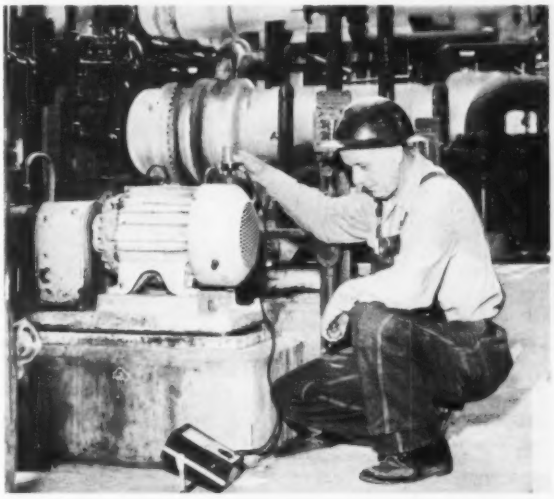
Since voltage across current coil of the wattmeter is a pure sine wave of running frequency, this method filters out all vibration harmonics except those corresponding to running frequency of shaft vibration. This is true whenever shaft is scored and out-of-round.

For a fixed frequency, voltage produced by a pickup has an amplitude proportional to the vibration being measured. It also has a fixed phase-angle relationship with vibration. A permanent magnet produces the magnetic field across an air gap. A coil suspended in this air gap moves as a function of vibration. Resulting movement develops a small, but measurable, voltage.

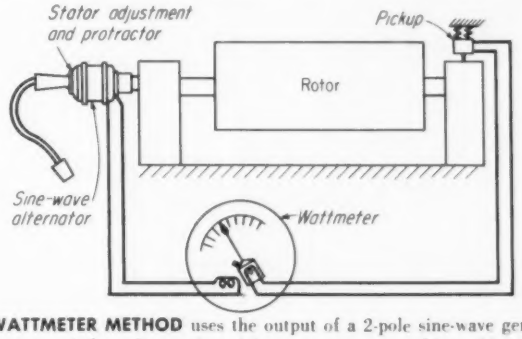
Pickup can be mounted permanently on a pedestal or next to the shaft where vibration is to be measured. Or you can hold it against the part to be measured for vibration. For 0.001-in. double amplitude of vibration at 1000 rpm, about 0.085 volts root mean square (rms) are generated in the pickup coil. Generator voltage varies directly as the frequency and amplitude of the vibration. Now let's see how vibration is detected and analyzed by some of the newest in-place instruments on today's market.



LIGHTBEAM vibration indicator has an 8-in. probe for reaching narrow spaces to take readings directly on the revolving shaft

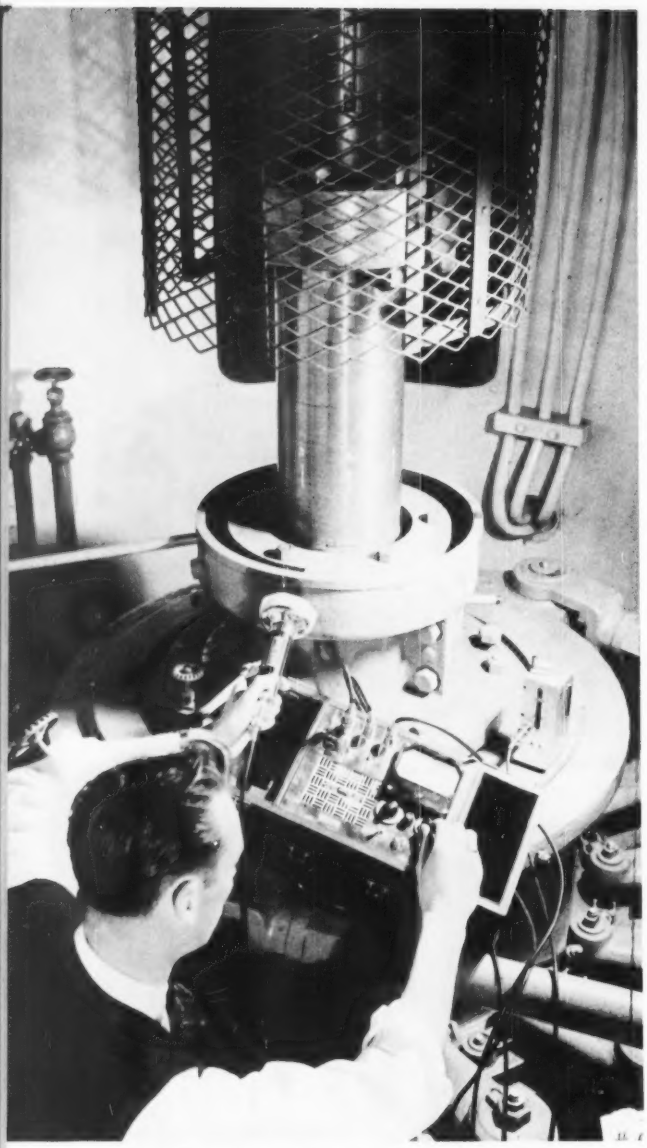


ALL-TRANSISTOR battery-operated instrument is handy for field work; it can also be carried directly to any machine in the plant



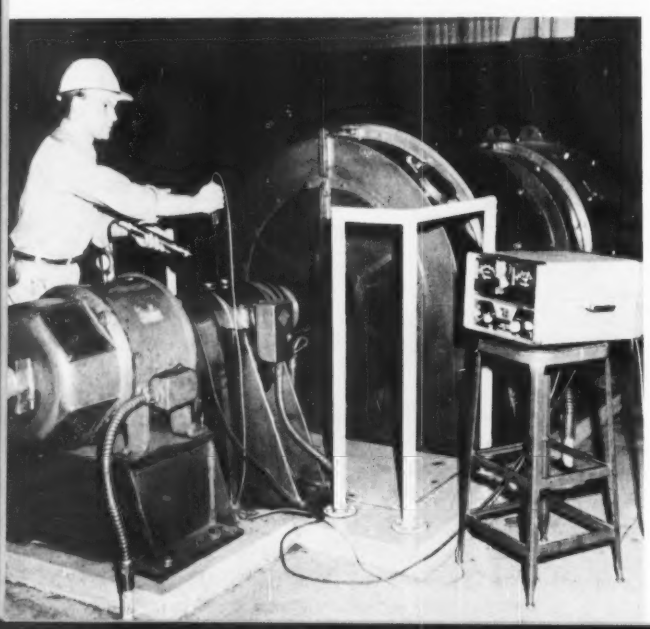
WATTMETER METHOD uses the output of a 2-pole sine-wave generator and the voltage of a pickup; wattmeter combines the two

Vibration analyzers



MECHANICALLY-TUNABLE vibration pickup is heart of this in-place balancing system. Calibrated scale gives rpm

VELOCITY TYPE PICKUP in this unit gives electrical signal, detects vibration as low as 0.000001 in. peak-to-peak



Portable vibration analyzers pinpoint vibration and other troubles while the machine is running. Today's electronic instruments help you analyze and make corrections without disassembling, making this test equipment ideal for field work. Since vibration is often the first warning of danger, a vibration analyzer can be your most important preventive maintenance tool.

In-place balancer, upper photo, has a tunable vibration pickup that isolates frequency of vibration caused by an unbalanced part. Once located, unbalance and resulting vibration can be corrected, regardless of magnitude. In portable systems of this type you can determine whether vibration stems from unbalance in the fan, the motor, or if it's transmitted from some other source. After tracing source, both your analysis and correction of unbalance become routine.

Heart of this system is the mechanically tunable vibration pickup. Calibrated scales indicate direct rpm reading. Although unbalance makes the pickup vibrate, a permanent magnet within the pickup remains stationary. Relative motion produces an electrical signal proportional to the force of the unbalance.

We know that a resonant type vibration pickup is most sensitive to effects of unbalance when it's vibrating at a frequency corresponding to the operating speed. When this pickup is tuned to resonance, effects of vibration at all other frequencies, regardless of their strength, are mechanically filtered out. Pickup then produces the strongest possible signal; noise level being an extremely small part. Because the maximum usable signal is obtained, a fine degree of balance can be achieved. An electronic amplifier, stroboscopic light, amount meter and other components comprise remainder of system.

Vibration analyzer, lower photo, does three jobs: (1) Picks out vibration characteristics of a system during operation. (2) Acts as a portable balancer when you know that unbalance is main problem. (3) Serves as a stroboscopic tachometer to determine speed of rotating parts. Once again a coil moving in a magnetic field provides the electrical signal upon which readings are based. Pickup will detect vibration at levels as low as 0.000001 in. peak-to-peak displacement at 100 cps.

Velocity signal generated by the pickup is electronically integrated, amplified and rectified in the console. Peak-to-peak displacement indication is shown on an amplitude meter, helping you to get the story in a hurry.

As a case in point let's check the vibration on a large turbine-generator unit. First, place the vibration analyzer pickup on the exciter-bearing housing. Assume meter shows a 4-mil vibration displacement. Next, place pickup on bearing housing between turbine and generator; here meter reads 5 mils. Governor and housing check gives a meter reading of 3 mils.

By checking every part of the large unit you have a complete summary of vibration conditions of both stationary and rotating components. If you find most vibration is

pinpoint trouble in rotating parts

in the turbine, open the exciter-shaft cover and place pickup at points of measurement. With the stroboscopic lamp triggered by the pickup, you learn the angle of unbalance in the turbine by viewing numbers that were previously placed on the end of the shaft.

The electronic system tells you the amount of correction needed to balance and angle at which you must make correction. Result: Vibration level is reduced to a maximum of 0.4 mils at any measuring point.

Here's how system works. Pickup detects vibration and converts it into an electric signal. This signal is passed to electronic circuitry inside portable console. Amplitude or displacement of vibration is shown in thousandths of an inch on a meter.

Another meter records frequency of the dominant vibration or, after turning on a variable filter, selectively tunes to any or all frequencies in the mechanized system. An electric signal also triggers a stroboscopic light in synchronization with frequency of vibration. So you can observe the angle of unbalance because stroboscopic lamp gives illusion that rotating part is standing still.

Here are some typical jobs that were handled in a power plant: (1) Unit located vibration in a blower system. Stroboscopic lamp showed three gear teeth broken from the main gear drive. Further running of blower would have wrecked the entire gear system.

(2) Using old trial-and-error method, blower assembly had been torn down and bearings replaced three times. This equipment found a bent shaft as cause of trouble.

(3) Maintenance men were making periodic checkup on a 450-hp motor with this analyzer. Vibration level wasn't excessive but frequency was higher than usual. This pointed to a change in condition of the bearings. Inspection showed bearings were dry.

Preventive maintenance is aided materially by vibration analyzers. For turbine-generators, draw up a log sheet. Have spaces to record vibration readings and locate reading points; take readings periodically. If amplitude or frequency increases over previous readings, take corrective steps. Plan for repair or replacement of defective parts at an opportune time.

These instruments measure three essentials of vibration: *displacement, frequency* and *phase*. Knowing these basic functions you can: (1) Measure displacements—to determine when the permissible vibration tolerances are exceeded. (2) Analyze or troubleshoot—to locate the faulty components exciting the vibration when tolerances are exceeded and to balance dynamically. (3) Locate the phase or angle of unbalance—so you can correct it without costly dismantling.

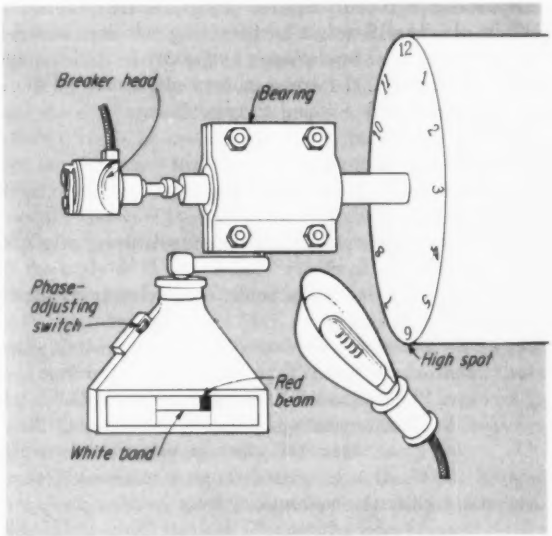
Another portable unit, shown in sketch, has a vibration meter and stroboscope as its essential parts. Here is the kind of information obtained on first run: (1) Measures vibration amplitude at all points in any direction. (2) Spots form of vibration, showing whether or not field balancing will correct it. (3) Determines high spot of each bearing. (4) Estimates angle of lag (angle between high spot and heavy spot).

Stroboscope consists of a flashing neon lamp, a breaker head driven by shaft of machine to be balanced and a special power supply, see sketch below. As shaft rotates, circuit is broken once each revolution by breaker head. Neon tube flashes instantaneously at each break. Since flashes are in step with rotation of part to be balanced, part appears to be standing still.

Breaker head has phase adjuster mechanism operated by remote control from a switch on the instrument. When phase switch is operated, position in transit where lamp flashes is changed so rotating part appears to be turning backwards or forward. At one point it gives illusion of being stopped in a desired position.

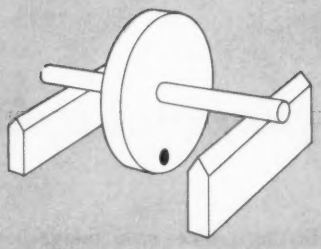
Vibrometer, placed against machine, indicates vibration amplitude. Combined with the stroboscope it shows exact relation between vibratory and rotary motions. Pin projecting from front of instrument picks up machine vibrations. This causes mirror to oscillate and small light source reflects from mirror on graduated glass scale. Narrow strip of light oscillating in step with vibrations appears as white band on ground glass scale. Width of this light band indicates amplitude of vibration.

Within vibrometer is a neon tube which flashes with a red light, in step with the stroboscope. Red flashing light passes through a slit and is reflected by the same oscillating mirror as the white light beam from the lamp. On glass scale, red flashing light beam appears above the steady white light. It shows the instantaneous position of vibratory motion, just as the hand lamp shows rotary motion.

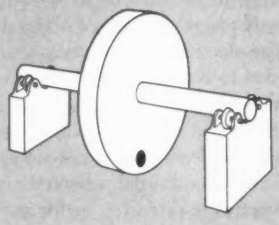


VIBRATION METER, stroboscope team up in this setup. Red light on meter shows vibratory motion; hand lamp shows rotary motion

3 *BALANCING—machines detect the amount and location of unbalance*



1 Static balance can be found by rolling the rotor on perfectly level knife edges



2 Rollers with narrow faces are also used for finding the static balance of rotors

Simplest balancer is a static device;

Since we now know how to detect vibration, let's look at the devices available to correct it. All balancing machines are weighing devices. They give information in terms of weight or vibration amplitude; the only measurements that can be used in correction.

Balancing machines may be compared on the basis of time required to do the job, accuracy, sensitivity and reliability of results. Whether you are considering a balancer for continuous production work, or the job type operation associated with maintenance, makes a considerable difference in your selection of a particular unit.

Simple classification for balancing machines is based on their method of operation: (1) gravity or static equipment (2) centrifugal force machines which may be static or dynamic. Here's a complete breakdown:

Gravity balancers:

1. Knife edge or roller arrangement
2. Vertical, nonrotating design

Centrifugal balancers:

1. Horizontal single-plane centrifugals using principle of static or forces
2. Vertical single-plane centrifugal using principle of static or forces
3. Horizontal double-plane unit using a dynamic principle of operation. These include the following:
   a. Plane separation through pivoted cradle
   b. Plane separation by finding nodal point
   c. Plane separation through electrical networks
   d. Plane separation through a mechanical compensation system
   e. Another scheme uses separate forces and couple indication, both kinetic and dynamic
4. Vertical dynamic, operating in two planes

Static balancing means simply to balance one weight against another. For example you can find static unbalance by allowing an arbor or mandrel to roll while on knife edges or static ways. Of course the knife edges should be perfectly level, Fig. 1.

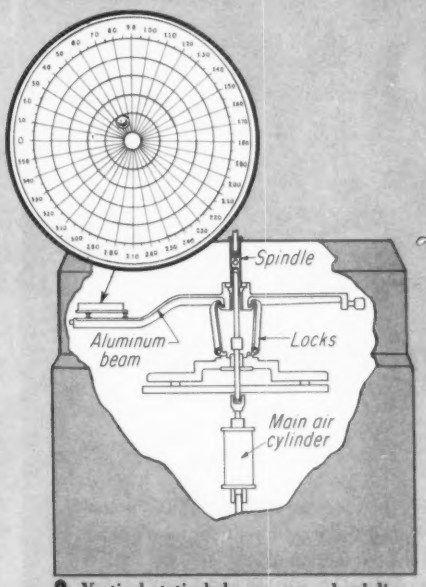
Pairs of overlapping narrow-faced rollers are also used, Fig. 2. Rollers are balanced, then mounted on rolling contact bearings. Amount and angular direction of unbalance are found in same way as with knife edges.

Assume the disk, Fig. 1, is out of balance statically. To balance you must either remove weight from the heavy bottom side or add weight to the top or light side. When the disk remains at rest in any position it is balanced statically. Weight of unbalance is offset by adding an equal and opposite weight. Same result may be had by simply removing the unbalance weight.

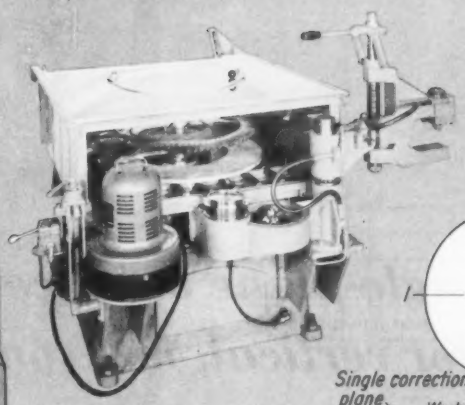
Vertical, static nonrotating balancer will tell you (1) if a part is in balance (2) how much weight must be added or removed (3) precise location for adding or removing weight to bring about balance.

Plumb-line principle lies behind the static unit, Fig. 3. Here a suspended weight is allowed to come to rest. Pivot point in spindle is a chrome-steel ball on a carboloy-tipped stem. When loading or unloading, beam is locked in position to separate ball from stem. Pressing a button raises workpiece into balancing position. A spirit level shows amount and location of unbalance. Press another button and the work can be removed for correction. Workpiece doesn't rotate but you can turn it 360 deg to constantly check accuracy. No electrical instruments are used with this machine.

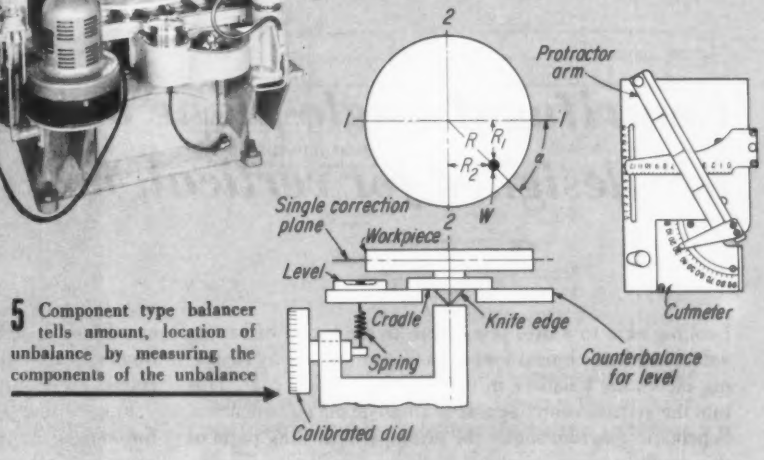
In this unit a universal spirit level is fitted with a direct-reading weighing mechanism. Circular lines on the level



3 Vertical static balancer uses plumb-line principle and the universal spirit level



4 Another vertical static balancer suspends body to be balanced from a pivot. Oil damper controls movement of body to speed the job



5 Component type balancer tells amount, location of unbalance by measuring the components of the unbalance

it finds trouble spots by gravity

indicate the amount of unbalance in practical values. Specs on weight and out-of-balance tolerances can be met by calibration. Example: Each circular line may be calibrated to read 0.1 oz-in., or 0.2 oz-in. and on up to high values. Calibration is changed by altering center of gravity as related to pivot point. Check-weight determines calibration of circular lines.

Machine in Fig. 4 suspends the part under test from a low-friction pivot. Work tilts in direction of unbalance. Suspension-by-wire is another technique used by some makers of balancing machines. However, in machine shown, amount of tilt tells us the amount of unbalance while direction of tilt tells its angular location. With platform released, unbalance in workpiece causes tilt in a direction proportional to amount of unbalance. Here, too, a universal level on the platform indicates amount and direction of tilt. Movement of this pivoted platform and workpiece is controlled by oil damping to help speed the balancing cycle. Six seconds after release you know amount and angle of unbalance.

Another balancer, which we'll call the pivot or component type, is shown in Fig. 5. Again the work is mounted on an adapter. Amount and angular location of unbalance is found by measuring components of unbalance.

Cradle is carried on a knife-edge pivot or a flat spring with a short free-length acting as a fulcrum. Unbalance causes the work to incline from the horizontal. Cradle can be returned to balanced position by adjusting spring tension or resetting a calibration dial.

Unbalance reading is with respect to axis 1-1. The component of unbalance is product of unbalance W and radius r_1. Then work and adaptor are rotated 90 deg with respect to cradle causing them to pivot about axis 2-2. The unbalance reading about axis 2-2 is a product of the weight W and distance r_2. The two unbalance components are then added vectorially by a cutmeter, shown at right of Fig. 5. The two component values, Wr_1 and Wr_2 are laid out on graduated scales. Protractor arm then indicates actual unbalance Wr along with the angle a.

Applications for static and single-plane balancing are a natural for (1) narrow parts like wheels, gears, fans, impellers, propellers, flywheels, etc. (2) in general, where axial size is much less than overall diameter and (3) where correction lies essentially in a single plane. Where areas of correction don't lie in distinctly separate planes, it's difficult to do anything but single-plane balancing.

Why static-pivoted machines? Claim is that they are more accurate than knife edges and that they give answers directly in amount and angle. Inaccuracy in centering the workpiece is simply compensated for whenever necessary on these machines. For production purposes, this machine makes it possible to establish balancing tolerances.

Static balancing may not be practical on narrow rotors if the body of the rotor isn't exactly perpendicular to the shaft. It may also be ineffective for long rotors. Reason is that separated ends then have a tendency to act independently during rotation. This tendency increases with length of rotor. Each end of rotor may be out of balance, not only by different amounts but in different angular positions as well. Condition known as dynamic unbalance becomes apparent only upon spinning the rotor.

For maintenance, static balancing knife edges (rollers) are quick, need no special adapters. For production balancing, the pivoted (vertical nonrotating) offers almost instant indication of the unbalance giving units of correction as well as location. Now let's look at some centrifugal units.

Centrifugal single-plane balancers are designed for vertical, horizontal use

Looking akin to a drill press, even to the extent of having a drill-head attachment for correcting unbalance by removing metal, the balancer in upper photo, facing page, falls into the vertical centrifugal-type single-plane classification. Schematic diagram shows the principal operating parts of this machine.

Rotating spindle carries the part to be balanced. One bearing supporting the spindle serves as a fulcrum, so placed that the spindle can vibrate around an axis perpendicular to the axis of rotation. The other bearing is free to vibrate. This latter motion is used to find the amount and angular location of unbalance. Spindle speed may be varied between 500 and 1800 rpm depending on design of the specific machine and its application.

Operation of this unit is quite simple. An unbalanced workpiece causes the spindle and its suspension to vibrate. This straight mechanical vibration is transformed into an electrical signal which shows up on a meter indicating amount of unbalance. Same electrical signal fires a stroboscopic light (once per revolution of the spindle) serving as a reference for the angular position of unbalance.

Pickup, which translates mechanical motion into an electrical signal, is similar in principle to that used in portable vibration detectors previously described. A movable coil suspended in the magnetic field from a stationary permanent magnet is mechanically connected to the vibratory portion of spindle suspension. Then, as vibration being measured imparts motion to the coil, a small alternating voltage is generated. This is the input signal for an electronic amplifier.

Amplifier output can be calibrated for any desired unit of correction. Thus the indicating instrument may show ounces, ounce-inches, length of solder needed for adding weight or depth of hole required for removing weight, to name a few of possible correction units.

Initial unbalance in the work being checked may be so large compared to the balanced condition that a single scale on the indication instrument is impractical. For this reason some balancers have a rough, medium and fine scale, each with its own calibrating potentiometer. The three ranges may be set in any ratio to each other, such as 1:10:100 or 1:2:5, etc.

Calibration of the three instrument ranges, when balancing a series of similar workpieces, follows an orderly pattern. Using the rough or coarse scale, a balance is reached on the first piece using balancing clay. At that point a correction is physically made on the part either by removing or adding weight. Then the medium and fine range potentiometers are adjusted until the instrument shows a simple fraction or multiple of the correction unit.

For example, with a calibration weight of 100 grams, the fine range is set to a meter reading of 100 and the medium range to a reading of 10. Next, additional unbalance of any convenient size is introduced and measured in the medium range (let's take 66 grams as an example). Then the selector is turned to the coarse scale with the proper potentiometer adjusted until the meter reads 6.6. Ranges for this particular part are then set at 1:10:100. That is, the meter reading in the fine range is direct in grams and must be multiplied by 10 in the medium range and by 100 in the coarse range.

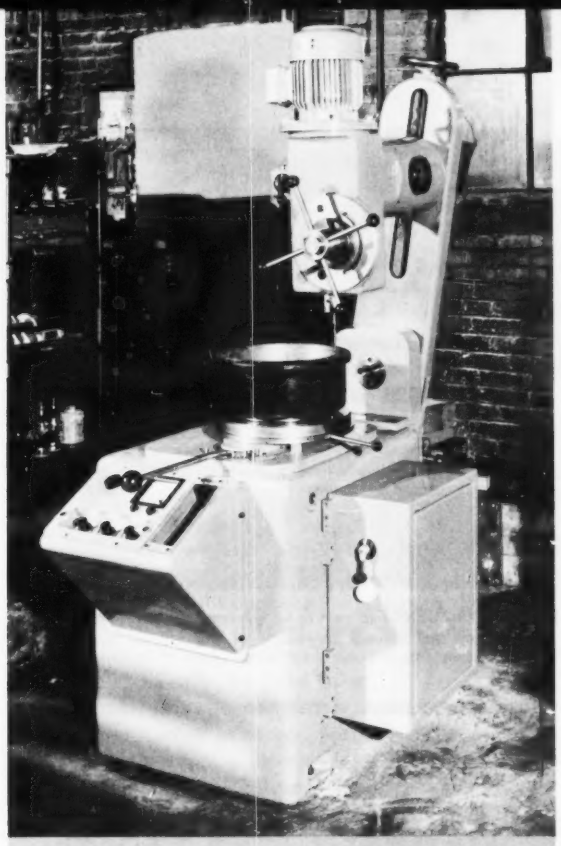
For purely practical reasons the potentiometers have graduated dials. Their settings and corresponding meter calibrations are recorded on a setup card which also shows the part number plus method or correction. In this way calibration for a particular part must be made but once. On succeeding workpieces the operator merely sets the dials for the initially determined arrangement and he is all ready to balance.

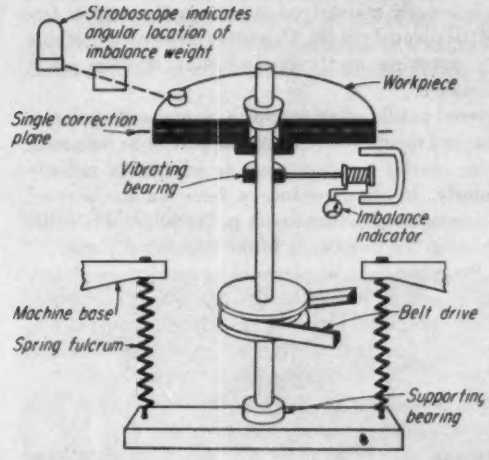
Vertical single-plane centrifugal balancing machines can be furnished with integral drilling or grinding heads. These heads are equipped with feed adjustments and can be positioned in any desired vertical, horizontal or inclined plane. On some machines drill depth measurement starts when the point of the drill contacts the work. In such cases, accuracy of unbalance correction isn't dependent upon the exact height or thickness of the part. Amount of indication on the meter can be directly correlated with the drill depth indicator.

Horizontal single-plane machine, shown in lower photo, facing page, is also used to balance impellers, flywheels, blowers, fans, clutches and other similar rotating parts that cannot be satisfactorily handled by the usual standing-static method, yet do not require a full dynamic balance. A photoelectric radial run-out indicating attachment enables you to measure and, if necessary, correct any run-out or eccentricity of the rim of 3- to 12-in. diameter parts in the machine prior to checking balance.

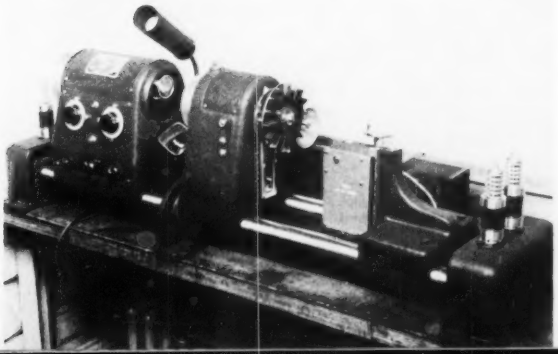
Amount of run-out is indicated directly in thousandths of an inch on the cathode-ray tube scale. When balancing, high or low spot is indicated in exactly the same manner as is the heavy or light side.

Before we discuss dynamic or 2-plane balancing, let's make an analysis of the two types of unbalance.



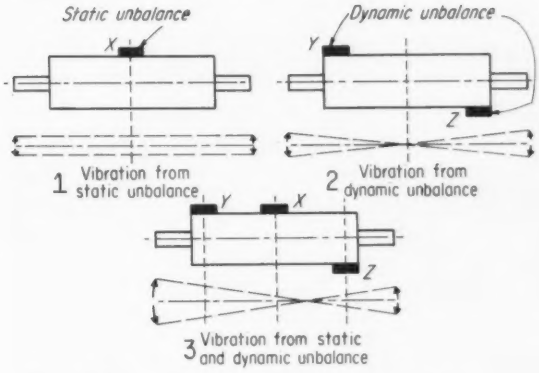


VERTICAL DESIGN is complete with drill head to remove right amount of metal from right spot. Schematic diagram shows how the free bearing vibrates to locate unbalance



HORIZONTAL UNIT has photoelectric radial run-out indicating attachment that measures run-out before checking the unbalance

Balancer types: a clarification



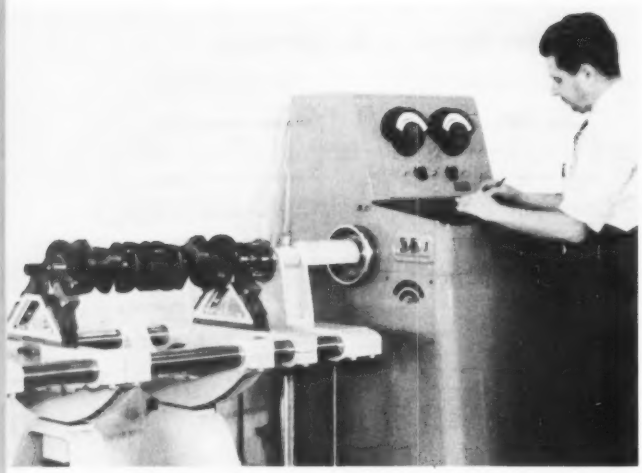
Terminology used in classifying some balancing machines may be a bit confusing. Reason is that both the nonrotating and the rotating single-plane units have in the past been dubbed as static machines. Now industry has agreed to call the centrifugal single-plane balancer a rotating unit while the nonrotating machine will be identified as a static machine.

Sketches, above, bring out some of the basic differences. Here we show a rigid rotor that's out of balance. Weight x displaces rotor's center of gravity from the true axis. In Fig. 2 weights y and z represent a couple, tending to twist the rotor from its axis. When unbalance occurs in more than one plane it's called dynamic unbalance and can only be detected when the part is rotated. Now, in Fig. 3, we have three weights representing both single-plane and dynamic unbalance. Carrying our analysis further:

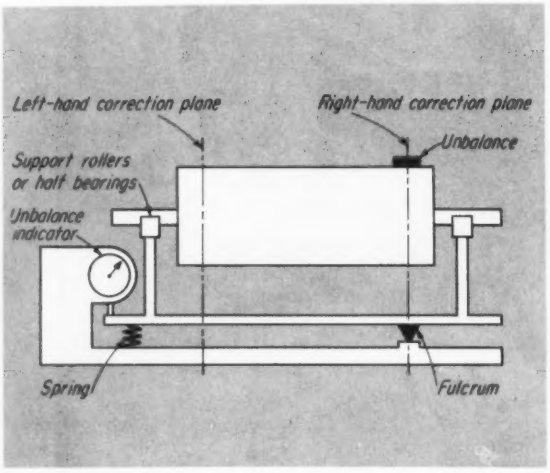
Vibration resulting from unbalance in Fig. 1 is single plane, taking the form shown by dotted lines beneath the rotor. In Fig. 3, vibration is solely from dynamic or couple unbalance, causing the rotor to whip or gyrate. Once again we find vibration caused by both single-plane and dynamic or couple unbalance. Weight x represents single-plane unbalance acting on the center of gravity between the two ends. A static or gravity test can detect the trouble. Solution is simply to place the rotor on knife edges and note its heavy spot.

Dynamic unbalance, represented by x and y, can be located only by a rotational or dynamic test developing a centrifugal couple. Remember that today's 2-plane balancers can either combine these forces with a single connection at each end or separate them into couple and force when this is most desirable. That's why separately designed machines and special methods described later in this report must be used.

From this we see that single-plane static balancing is better termed gravitational balancing where centrifugal force takes no part in the measurement. Single-plane balancing of either the static or centrifugal type is suited for use on disk-like rotors of short axial length. So a single-plane machine is either nonrotating and tilts in direction of unbalance, as we have seen on previous pages, or it rotates.



PIVOTED CRADLE machine finds sum of moments of centrifugal forces caused by the unbalance, with respect to the fulcrum axis



ROTATIONAL FREQUENCY of part to be balanced is usually maintained at or near the natural frequency of the pivoted cradle

Dynamic type machines indicate unbalance in more than one plane

With an understanding of the various single-plane balancing machines under our belt, let's consider the horizontal, 2-plane, dynamic types available. These machines are finding wide use in plants as preventive maintenance instruments, and quickly pay for themselves in dollars saved.

Dynamic balancers aren't easily classified since they must meet both general and specific requirements. For example, they must give understandable information on *amount* and *angular location* of correction needed in each of two selected planes perpendicular to the axis of rotation in which the workpiece turns about. These planes are selected by limitations imposed by the work itself, not by inherent restrictions of the balancing machine.

There are two general schemes for indicating unbalance in two planes: *plane separation* and *separate force and couple indication*. The plane separation technique may be carried out by any of the following methods: (1) pivoted cradle (2) finding nodal point (3) using electrical networks or (4) mechanical compensation.

Plane separation through a pivoted cradle requires the unbalanced part to be supported on adjustable support rollers or half bearings, as in photo and sketch above. Supports or bearings are attached to a cradle carried on a fulcrum in one of the two selected correction planes, while unbalance effects in the other correction plane are measured. The cradle is spring-supported at a point removed from the fulcrum. Unbalance in the left-hand correction plane is shown by an indicator that measures motion between the cradle and machine base at a point removed from the fulcrum.

Pivoted cradle provides a means for determining the sum of the moments of the centrifugal forces created by unbalance, with respect to the fulcrum axis. Moment of unbalance forces in the right-hand plane is zero, but moment of the unbalance forces in left-hand plane is shown on the unbalance indicator, as diagram above indicates.

By turning the workpiece end for end in the machine, or by moving the fulcrum into the left-hand plane, unbalance in the right-hand plane is found without effect from unbalance in the left-hand plane.

One type of pivoted cradle has a natural frequency about the fulcrum. Rotational frequency of the part to be balanced is usually maintained at or near the natural frequency of the pivoted cradle. This gives maximum machine sensitivity, meaning maximum indicator reading for a given unbalance.

The pivoted cradle often carries a compensating device that is attached to and rotated with the part to be balanced. This device carries a weight that is adjustable radially and angularly. It can introduce a force on the pivoted cradle whose moment with respect to the fulcrum is equal and opposite to the unbalance in the correction plane.

When the pivot in one plane of correction is closed, photo, the cradle is locked to the base. This eliminates effect of any unbalance forces in this plane. A moving coil in the field of a permanent magnet receives the same motion as the cradle, and generates an ac voltage signal that gives a true measure of unbalance. An indicating system instantly translates the signals electronically from the vibration pickup into both angle and amount indications.

To change the plane of correction, the operator changes the position of the pivot shifter. This automatically opens the pivot in the desired plane of correction while locking the other plane.

Angular position of unbalance shown on the angle meter is quickly located on the workpiece. It's done by rotating the calibrated reference wheel by hand until the indicated angle is in line with the reference pointer. Heavy portion of the workpiece is then on the horizontal or any other preselected angular location. A polarity or angle switch on control panel enables operator to secure an indication which will place the heavy portion of workpiece in either the front or rear of the machine. Another type dynamic balancer works on the nodal point principle.

Nodal point

Null point, point of zero or minimum vibration is referred to as the nodal point method of plane separation. As sketch below shows, the workpiece is flexibly supported on bearings. A nodal bar attached to the bearings has the same motion as the axis of the workpiece.

If weight in right-hand plane is the only unbalance in the rotating workpiece, axis of the work will move as shown. Motion at the right-hand bearing will be greater than motion at left. But there won't be any vibratory motion at point *0* on the axis or on corresponding point on the nodal bar. So point *0* is the null or nodal point. Its location corresponds with center of oscillation for a center of percussion in the right-hand plane.

Unbalance indicator placed at *0* gives no reading because of unbalance in the right-hand plane. But it will indicate any unbalance that may be in the left-hand plane. Of course there's another nodal point that will indicate unbalance in the right-hand plane that's not influenced by unbalanced in the left-hand plane.

Photo, below, shows this type machine being used to balance a small armature. Spring suspension isolates the unbalance from the motor drive and other sources of outside vibration. Unbalance of the spinning rotor causes flexibly mounted bearing structures to vibrate synchronously with the rotation. This vibration is transmitted to transducer units that convert the mechanical vibration into corresponding electrical pulsations. These, in turn, are amplified and plotted on the vertical scale of a cathode-ray tube. Scale reading, or vertical length of the trace line, is proportional to the amount of unbalance and may be calibrated to read in any unit of correction that is practical.

In this machine no mechanical coupling errors are introduced. Reason: No coupling is needed, either for driving the rotor or to secure a phasing reference for determining the position of unbalance.

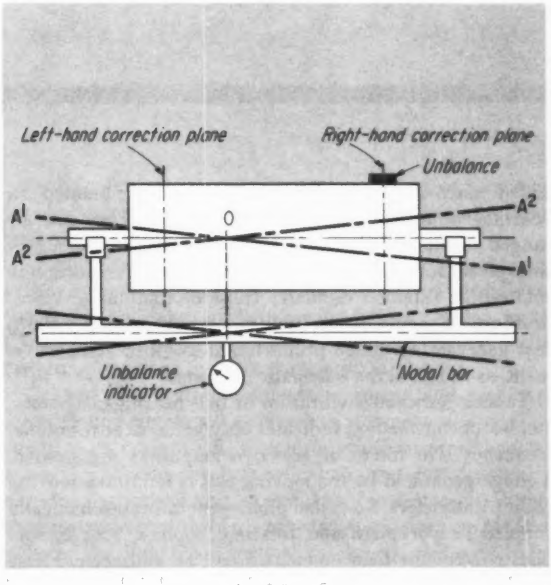
Phasing mark on the rotor helps you find position of unbalance with a beam of light. Mark may be a single spot of light-reflecting paint, a radial tab of light-colored tape or a special friction sleeve collet with radially marked scanning disk, placed at any random angle on end of the rotor or shaft and facing the headstock.

Photoelectric scanning head in headstock projects a focused beam of light onto end of the rotor. Rotation of work with its reference phasing mark modulates the light beam, causing a momentary change in light reflected back through the scanner lens system onto the photo tube. Momentary light change creates a pulse in the photo-tube circuit which is amplified and plotted horizontally on the cathode-ray tube scale. It appears as a pip on one side of the vertical trace line. The entire photoelectric scanning head may be revolved around its axis with a handwheel. This axis is coincident with the extended center line of the shaft being checked. Thus by turning the handwheel, the timing of the pulse signal can be changed in relation to the unbalance signal from the transducer.

Position of unbalance is quickly found by turning the handwheel a fraction of a revolution. This moves the phasing pip to the extreme end of trace line. If the spinning work is now stopped and positioned so its phasing mark is lined up with the projected spot of light, the point at which indicated correction should be made is opposite a fixed red reference pointer. With pip at bottom of trace line the heavy side is indicated; pip at top indicates light side.

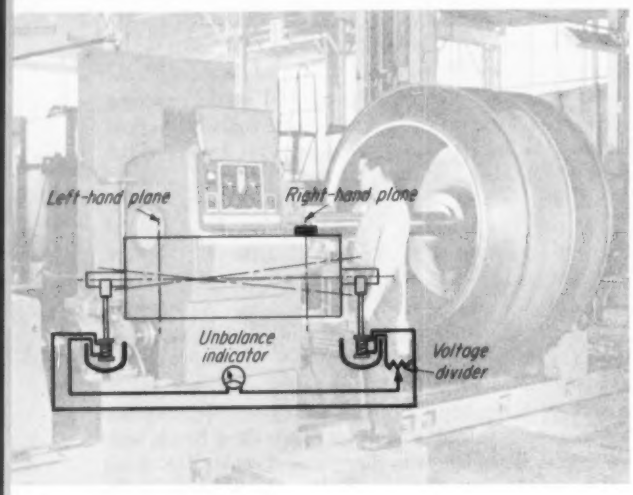
Planes may also be separated by electrical networks. Three machines that do this are shown on next page.

NODAL POINT method of plane separation has a bar attached to bearings; complete assembly has the same motion as the workpiece



PHOTOELECTRIC scanning head projects a light beam onto the end of the rotor; this helps find unbalance by turning a handwheel

Here are three ways of plane separation

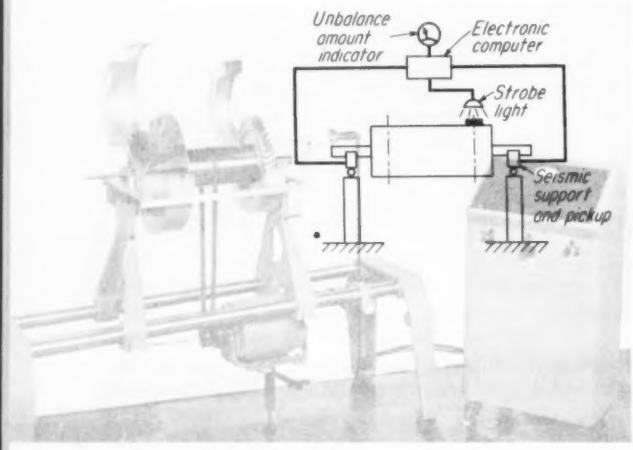


VOLTAGE is generated in coils as they move in the magnetic field

Plane separation technique by electrical networks is basically the same in all machines using this method. However, unbalance indicating methods are different. In the three machines shown, the first uses a maximum-reading indicator, second has a strobe light with an electronic oscillator and third uses vector indications through addition of components—all do the same job but in a different way.

For plane separation, electrical pickups are used to sense motion of the workpiece. Then proper network arrangements are set up so cross effects are cancelled out electrically. Once proper resistance settings are established in the networks, balancing can be done by running the rotor and flipping a switch for both the left and right end correction indications.

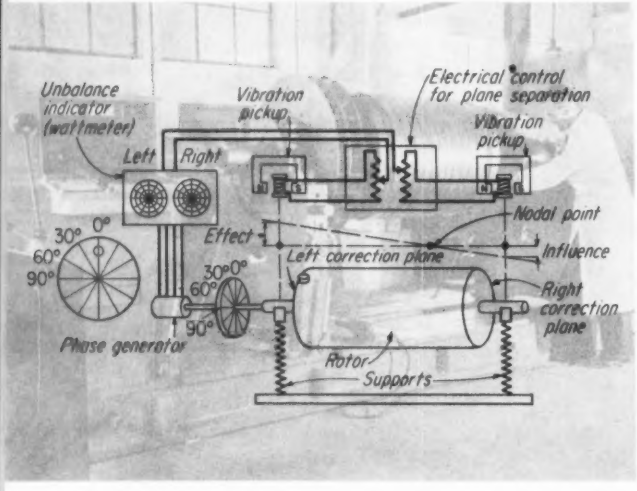
Besides measuring motion, these balancing machines normally measure phase or angle of unbalance by one of the following methods: (1) optical means (2) oscilloscope



UNBALANCE VIBRATION is sent from shaft through platform

Second machine, photo left, is tackling a rotor balancing job. Rotor to be balanced is carried on two ball-and-cup mounted work supports, with a degree of freedom in a horizontal plane. As rotor spins, the geometric bearing axis oscillates across its inertia axis. This unbalance vibration is transmitted from the rotor shaft through the rotor platform by means of a viscosity damped coupling to a transducer tube. At this point the mechanical motion is converted into an electrical signal.

Signal selected from either the left or right side of rotor is mixed with a signal from the opposite side of rotor. This signal is of such amplitude and phase that the net result becomes proportional to exact unbalance correction needed



WATTMETER SYSTEM uses natural frequency below balancing speed

Third machine photo, left, has workpiece mounted on bearings attached to vertical leaf springs. They are arranged so their natural frequency, with mass influence of workpiece, is always below balancing speed. As workpiece rotates, the supports oscillate. These oscillations or vibrations are transmitted to moving coil type vibration pickups that generate a voltage proportional to vibrational movement, as shown in the schematic drawing.

To strip unwanted vibration of ball bearings, supports, etc, wattmeter method indicates only voltages at rotational frequency. No filters or selective amplifiers are needed. Voltage generated by the moving coil is fed to the moving coil of wattmeters. So-called phase generator, mechanically coupled to workpiece and rotating in phase with it, supplies current for field or current coil of wattmeter. Phase

by electrical networks

(3) a stroboscopic lamp (4) a wattmeter with an adjustable sine-wave generator or (5) a meter.

First machine, photo, left, shows the workpiece flexibly supported on bearings, and having coils free to move in fields of permanent magnets. An unbalance in the right-hand plane causes axis of the workpiece to move when work rotates. Voltage is generated in the coils as they move in the magnetic field. But voltage on right-hand side is greater because motion caused by unbalance on that side is greater.

Voltage divider reduces voltage to a value equal to that on the left side. When these two voltages are added, resultant voltage supplying the unbalance indicator is zero. Electrical network provides a means whereby the unbalance in right-hand plane may be ignored.

A similar network provides a means for nulling out the effect of unbalance in the left-hand plane and for reading unbalance in the right-hand plane. Here, the unbalance indicator shows unbalance in either the left- or right-hand plane as a switch causes it to receive voltage from one network or the other, see schematic diagram at left.

Photo shows a double-inlet fan wheel being balanced. Wheel weighs 3800 lb, shaft weighs about 1800 lb. Wheel is being balanced within a bearing movement of 0.0003 in. displacement, or 0.0006 in. total bearing vibration at 150 rpm. Operator measures and locates unbalance in each of the two correction planes.

Correction is made by welding at the indicated angles, while the part is in the machine. To check for final balance, fan is rotated again.

This type of balancer may be set up to either locate or measure, or to both locate and measure, single- or two-plane unbalance. Meter accurately measures bearing movements of 0.000025 in. at 300 rpm giving extreme accuracy.

for balancing the rotor in a preselected correction plane.

Resultant signal is fed to an electronic filter and preamplifier combination that amplifies the desired signal while rejecting spurious and unwanted frequencies caused by rotor bearings and building vibrations (frequencies not related to unbalance vibration of the rotor). An attenuating or multiplying network adjusts sensitivity of the balancer to read directly in user-desired units of unbalance in the rotor. This clean, greatly amplified signal is then indicated through a vacuum tube voltmeter in user-selected unbalance units and shown graphically on the oscilloscope.

An oscillator tuned to the frequency of the rotor speed is slaved by the unbalance signal, causing a strobe lamp to flash at the moment the heavy spot of the rotor appears at a predetermined point on the upper half of the rotor.

Units of unbalance can be converted by means of a graph into drill depth. Drilling attachment, adjusted to the required drill depth by means of a telescopic sleeve, exposes the drill in directly calibrated increments of 0.005 in. Other circuitry permits a measurement of total rotor shaft movement. This includes bearing noise and also lets you observe the movement signal on the oscilloscope.

Balancing machines that do precision work, such as gyroscopes, must reduce unbalance below the random motion caused by bearings. This machine measures unbalance smaller than that produced by bearing imperfections.

generator acts as a transmitter to convert direct current supplied to it during each rotation into a sinusoidal voltage through matched resistors.

Magnitude and phase angle of resulting alternating current is independent of speed and almost free of harmonics. Current is also taken off by a second pair of brushes set at 90 deg to first pair. This enables a second current to be tapped off, lagging the first current by 90 deg.

Current obtained corresponds to cosine and sine currents. Both currents are switched to wattmeter and used to energize its current coil which only indicates mechanical vibrations. Frequency is identical to rotational frequency of rotor. Indicating unit, sketch, left, is a vector type light-spot instrument with two wattmeter measuring units. One deflects the light spot vertically; second unit acts independently and deflects light spot horizontally. Indicated result appears as a sharply defined point of light on a two-dimensional circular scale. Zero position is at center of the scale. Indicated results can be fixed with an electromagnetic locking device. Wattmeter indicates only amount of unbalance in phase with the reference current; superharmonic vibrations aren't included.

In the vector type light-spot instrument, both wattmeter systems are fed simultaneously—one with the cosine current, the other with sine current. Both units are deflected according to magnitude of the components. Light spot appears at end of the resultant vector, thus indicating unbalance directly in terms of distance from zero and angular position on a scale graduated in polar coordinates. Other machines separate planes by mechanical compensation.

These machines separate planes through mechanical compensation while separating force and moment indications

Plane separation through mechanical compensation means introducing a countermotion into the bearings in which the work rotates until a smooth running condition is obtained. At this point the machine indicates the magnitude as well as the location of unbalance in oz-in., or on more specialized work in any desired units such as number of holes to be drilled or slugs to be added, etc. See top photo.

Work is driven from face plate by a band or a coupling. It rotates on open rollers and unbalance causes it to vibrate in a vertical plane on the carriages and pivot beams. Beams, pivoting around a set of bearings in the rear, rest on vertical pins that transmit motion to cross levers supported by ball bearings and carrier springs.

By turning knobs, length of springs is adjusted to natural frequency corresponding to the imposed weight of the workpiece. Rear end of cross lever carries a coil that moves up and down in a stationary magnet, producing an alternating current, upper sketch, facing page. Current is amplified, rectified and registered on an ammeter. Reading, then, is only an indication of the movement of the workpiece.

Variable countervibration is developed in machine headstock entirely separate from the vibrating bearing leverage. With this countervibration, machine compensates for and finally neutralizes the unbalance vibration. Bearing leverage is then stationary and ammeter reading is zero.

To cancel out unbalance vibration of unknown phase and magnitude you must vary the counterforce. This is done either by changing the relative phase at which the countervibration is introduced or by adjusting the amount of countervibration from zero to a maximum.

Phase of countervibration is changed in the following sequence: Face plate drives an eccentric over a differential. If the angle wheel is turned, the entire differential revolves. Thus the relative position of the eccentric to the face plate can be changed through a full 360 degrees. Differential housing has a graduated disk indicating relative angle of counterforces. Second disk turns with eccentric, carries a marker and serves purpose of lining up the workpiece so heavy spot is in the rear. A pin held against rotating eccentric transmits motion to the pivot bar. By turning wheel a fork can be moved along entire length of pivot bar, picking up vibration and transferring it to a swivel frame.

Closer the fork is to fulcrum of the pivot bar, the less vibration is transferred to the swivel frame. If fork is positioned directly underneath the pivot point, no vibration is picked up and, therefore, no counterforce is introduced. As fork is moved to the right of the pivot bar, more and more vibration is picked up, thus more vibration is produced. Swivel-frame vibrations are transmitted along entire bed length by an oscillating shaft. Cams and counterstrings bring the countervibration to a nodal bar, then back to the bearing supporting leverage.

When phase of countervibration is adjusted to be opposite, and magnitude is exactly the same in size as unbalance vibration, motion of the bearing leverage will cease. Unbalance of rotating workpiece forces leverage down, while counterforce is directed upwards. At this point of equilibrium the indicator shows exact amount of counterforce needed to bring work into balance, and marker points at angular position at which counterforce has been applied.

Operator does all balancing by turning an angle wheel until the ammeter shows a minimum reading. He then sets amount for zero ammeter reading. Readings are obtained in one run for both planes of compensation. Amount and counterforce angle can be read off the same machine in oz-in. Indication may be in drill depth at a certain radius, gram scales, etc.

Separate force-and-couple indication balancing machine is shown in lower photo, while sketch shows the same machine diagrammatically.

Resonance in vibrating systems is the fundamental principle behind this machine. For example, when a diver jumps up and down on the end of a diving board, he quickly observes that by synchronizing his efforts with motion of the board, it takes very little exertion to keep the board in motion and make it bend to its maximum amplitude. When this condition is set up in the diving board, it's

said to be in tune, or resonating with the exciting force.

A flat spring in each machine support serves the same purpose as the diving board. So when a rotor to be balanced is mounted on the trunion bearings it becomes the diver. The exciting force originates when the rotor spins, causing the unbalanced masses to generate centrifugal forces.

Since the centrifugal force induced by unbalance acts to bend the flat spring downward once each revolution, vibration frequency in cycles per minute will have the same numerical value as the rpm of the rotating rotor. Speed of rotation at which the system resonates is referred to as the critical speed. It's very difficult, of course, to hold the rpm of any rotor at the exact resonance (critical speed). But this machine overcomes this condition by spinning the rotor slightly over critical speed and letting it coast through the critical speed for unbalance readings. Instead of having a continuous meter reading, the operator reads only the peak valuation, which is the accurate amount of unbalance indication shown by this machine.

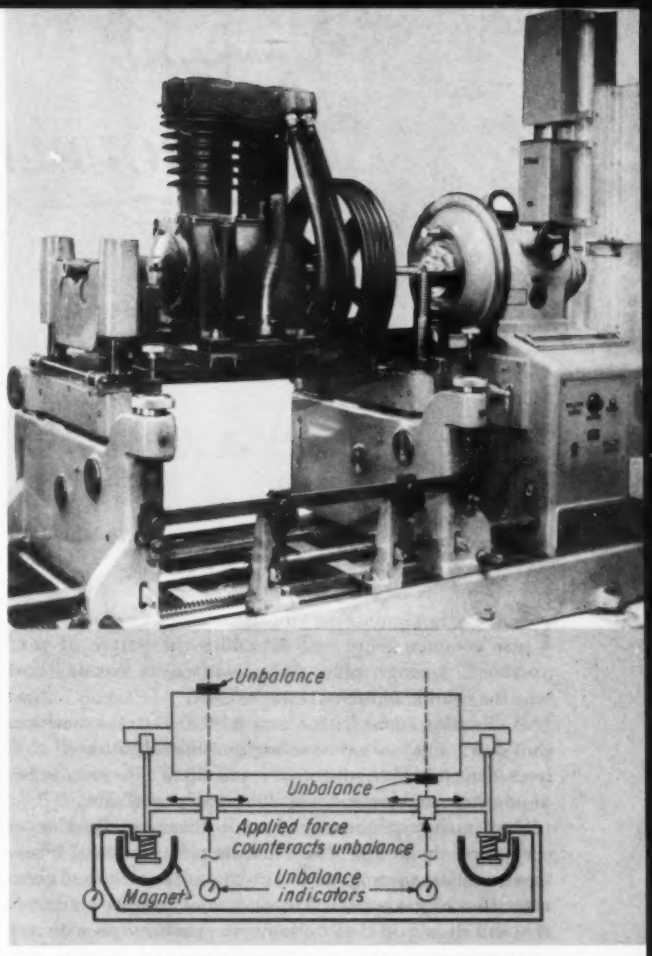
As noted with the diver, it's the peculiar property of a resonating system, or of a system rotating at critical speed, that a very small force produces a very large amplitude of spring deflection. But at speeds above or below critical speed the effects are greatly reduced. Even though critical speed is nowhere near the operating speed of the rotor, the unbalanced mass produces its greatest effect at the critical speed of the system. By analyzing unbalance only during the period of critical speed, this machine determines very minute amounts of unbalance.

Motion of vibrating system in resonance is converted into electrical impulses through electromagnetic pickups. These impulses are amplified electronically; they trigger a stroboscopic light that indicates either the phase or angle of the unbalance in the system.

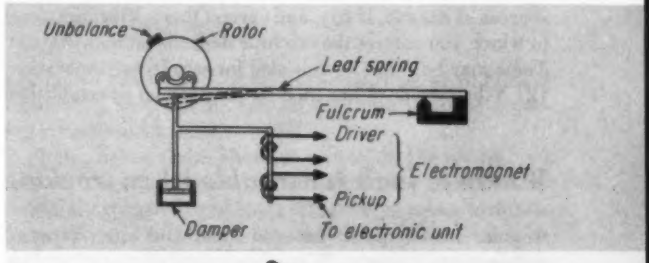
Drive system for the machine eliminates need for a drive coupling or special tooling, regardless of job to be done. It can be positioned anywhere along the length of the machine by actuating the motor position control handle. By pressing the moving drive belt against the outside diameter of the rotor, it can be spun to the desired speed. When it's running at the right speed (in excess of critical speed) the operator lifts the belt off the rotor and twists the brake control handle clockwise to shut off the motor. This eliminates all vibration from the drive system. You can take accurate meter readings while the rotor being balanced coasts through its resonance or peak reading.

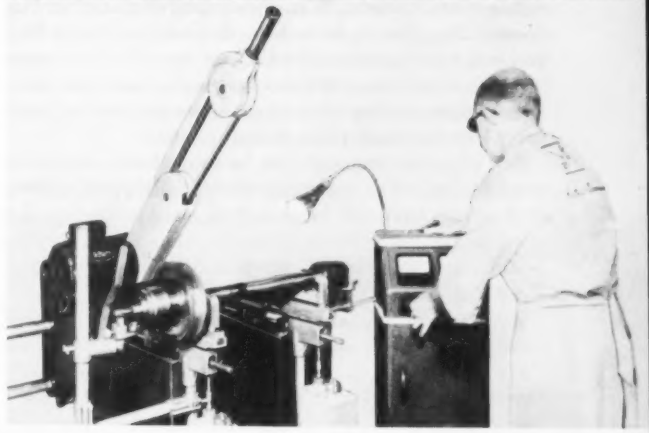
Turning the handle further, (clockwise) locks the belt. The belt can then be used as a brake to stop the rotation of the rotor being balanced. A counterbalancing device on the drive arm allows the operator to leave the drive in any position that he desires.

Ranking high among other advantages of this balancer are the following features: (1) Unit can be adapted quickly from one job to another. (2) Machine has high versatility over a wide range of work. For some jobs, half bearings may be substituted for standard trunnion bearings. Also, V-blocks can be used for a wide range of shaft diameters, especially those shafts that are mounted in their bearings. As no critical alignment is needed, these V-blocks can be clamped directly on the bearing castings, helping to balance special jobs in a minimum of time.



MECHANICAL COMPENSATION system of plane separation introduces a counter motion into the body being checked for unbalance





SEPARATE FORCE and couple indication balancing machine employs the principle of resonance in the vibrating system itself

4 TROUBLESHOOTING

Here are the ABC's of field testing

First step in eliminating vibration-caused headaches is to use common sense and determine the nature of your problems. Amongst other things this means learning how long the trouble symptoms have existed.

If vibration stems from a source other than the machine, shut down unit and measure background vibration. If analyzer detects major source of transmitted vibration is beyond main machine, note this for future correction.

Start main equipment and again measure vibration at critical points on machine. Find the prime cause of vibration by relating frequency to various components and characteristics of the system. A stroboscopic lamp or a vibrometer will show you if vibration is in synchronism with any rotating or oscillating components.

After correcting the major cause of vibration, again measure vibration at critical points. Find remaining sources of trouble, if any, and correct them. Vibration level to which you correct the machine depends on many things. These may be: (1) Level needed for satisfactory operation. (2) Vibration level specified by commercial or established tolerances. (3) Background level beyond which vibration level cannot be reduced without correcting sources of trouble outside machine. (4) Lowest level you can obtain without major redesign. (5) Level which has proved OK.

If several machines can add to your problem, you may have to shut them all down and run individually until trouble is found. But this isn't always practical.

As explained under *vibration measurement*, when vibration is measured at critical points on a machine, you may detect a beat or combination of two predominant sources of vibration. This results in unsteady frequency reading, unsteady amplitude reading and periodic surging of vibration that can, at times, be felt or heard.

Vibration sources can be separated by: (1) operating components separately (2) using two different pickup probes and two positions of analyzer switch (depending on type) to favor one frequency over the other (3) using a filtering system so analyzer responds to only one frequency band (4) measuring vibration at different points on machine to find the vibration that's most easily transmitted.

Where to look for trouble when tracking down vibration patterns

Angular misalignment between inner and outer races of rolling-contact bearing is another source of vibration. This usually takes place in the endwise or axial direction. Vibration frequency is equivalent to rotor speed in these cases.

Excessive clearance in sleeve bearing causes a difference in amplitude reading when taken on bearing housing, compared with amplitude taken directly on shaft.

Belt vibration frequency can be equivalent to rotational speed of the belt or a multiple of rotational speed. Here a stroboscopic lamp will freeze a chalk mark on the belt. But it will freeze or stop the mark in one certain area, or several positions if the belt vibration is a multiple of the rotational speed of the belt.

Aerodynamic vibrations can result from unequal blade pitch of a propeller-like system if axial force against one blade isn't equal to axial force against remaining blades. This causes vibration at the same frequency as rotating speed. It's mainly, but not totally, acting in endwise or axial direction. Duct work, shrouds, piping, etc can be excited to resonance by gas or liquid flow through system.

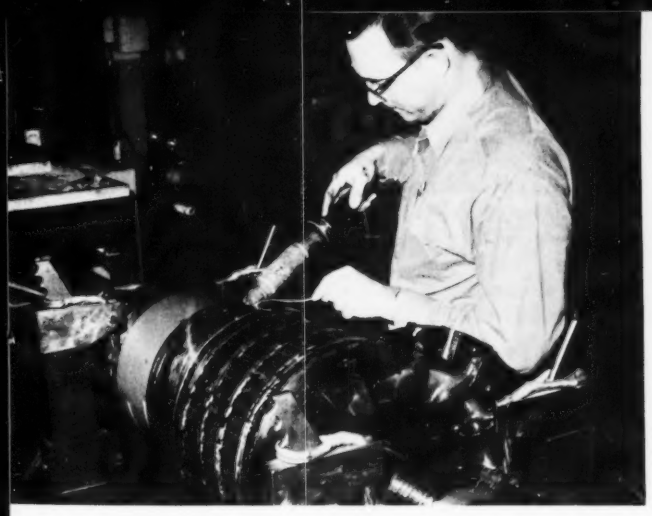
Hydraulic vibrations can stem from cavitation in pumps, excited by fluid flow, etc. Electrical vibrations, as in transformer cases, are induced by alternating electromagnetic fields. Torque pulses in single-phase electrical motors result when rotor movement through one revolution is not constant and jerks as rotor passes each pole.

Frequency of vibration in a gear set depends on nature of trouble and design of gear assembly. Vibration can also be caused by an eccentric pitch circle of two gears.

Oil-whip vibration in lubricated sleeve bearings occurs when equipment is designed to operate well above critical shaft speed. Then, whip takes place in bearing at lower than rotational speed. To solve this problem change bearing design or lubricant.

System resonance takes place at or near operating speed within a system. At this point small vibrations are magnified. So shut off power source and note how amplitude of vibration varies as equipment coasts to a stop.

There are many other causes of vibration, but these few will give you an idea of what to look for when trouble starts.



REMOVE WEIGHT from blade by grinding after finding unbalance

ADD WEIGHT to rotor by soldering after analyzer gives answer

To balance a unit you must add or remove weight

Add temporary balance weights before making permanent corrections. Here are some ideas: (1) Use balancing clay that adheres to rotating part. (2) Add bolts, nuts or washers to through holes, tapped holes or threaded studs. (3) Clip weights and U-clamps so centrifugal force helps hold weights in place. (4) Use laminated layers of tape for fine correction on very light parts. (5) Solder weight to metal baling bands strapped on part being balanced. You will usually be safe if you look for the original balancing correction made by the maker and use the same method.

After you balance with temporary corrections add or remove weights permanently. But remember that permanent weights must equal temporary weights in oz-in. Try these helpful hints: (1) Weld on metal weights, but don't forget to account for weight of the weld. (2) Add solder. (3) Add bolts, nuts or washers to through holes, tapped holes or threaded studs. (4) Drill, grind or fill. (5) Fasten U-clamps.

When drilling, grinding or filling remember that weight must be removed at opposite position to spot where weight would be added for correction. A shift in the reference mark indicates that weight isn't being removed in exactly the right location. So remove succeeding weight with relation to weight already removed. You will find that this is in direction opposite to the shift of reference mark.

Practical ways to protect your equipment against vibration

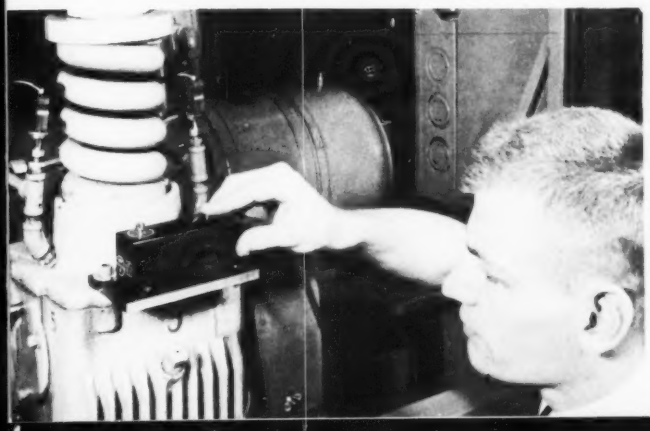
Switch, photo, below left, automatically shuts down equipment when vibration exceeds normal level. It also sounds an alarm or lights a warning signal. This protection is not offered by devices that measure only eccentricity of a shaft. The switch is used on both attended and unattended equipment. Reason: Many troubles progress too rapidly for operating personnel to take action in time to prevent failure.

Because sensitivity of switch increases with frequency, it senses either increases in amplitude at the operating speed or high-frequency chatter, noise or shock associated with the many types of vibration troubles.

You can also install supervisory instrumentation. This equipment can be hooked up to the bearings of all critical equipment, so operators can see vibration levels by glancing at instrument panels.

Photo, below right, shows a system that measures and records vibration, speed and valve position, shell and differential expansion, and shaft vibration of steam turbines. Its purpose is to provide the turbine operator with both current and past information on the mechanical performance of the turbine—info that often can be used to avert severe damage and unscheduled downtime. By knowing when potentially damaging conditions are developing, the operator can take proper steps to correct these conditions.

VIBRATION DETECTOR stops machine if vibration is excessive



SUPERVISORY INSTRUMENTATION tells you how machine is acting

How about vibration tolerances?

I asked, "Why don't manufacturers stamp vibration tolerances, based on amplitude and speed, on their machines? Also, why not stamp the machine with the vibration level to which it has been balanced at the factory?" Many answers came in—here are some of the highlights:

". . . With improved balancing methods, turbine-generators for example, usually operate with a vibration level around one mil or less. It's safe to run a machine at 5 or 7 mils vibration, but we wouldn't want this 5 or 7 mils staring everybody in the face on the nameplate. Purpose of balancing isn't just safety but efficient operation and longer life, without downtime."

". . . If vibration limits are to be stamped on a machine they should be defined by allowable amplitude for a machine mounted on pads, at running speed, and measured at a specific location. It's not practical for the maker to specify a definite vibration tolerance for the installed machine. Actual vibration amplitude depends upon factors beyond his control, such as degree of flexibility in machine mounting, coupling misalignment and vibration transmitted from adjacent machines."

". . . It takes a good field engineer with equipment to run special tests to see if a particular vibration level is harmful. Best way to evaluate vibration level is on elastic mountings as defined by NEMA. Vibration frequency, if caused directly by rotor unbalance, is at same frequency as the shaft rotation speed."

". . . Since we can't eliminate vibration completely, our utility superintendents often ask, 'How much vibration can be tolerated before shutting down?' Because of varying designs of both turbine-generators and their supporting structures, this question has no exact answer."

". . . Exciting force or forces causing a structure to vibrate usually start in the rotating elements. It's transmitted through shafts to bearing, then to the structure. So logical point for vibration measurement is on shaft itself. But, since some shafts aren't visible, bearings are next best place to measure vibration. Shaft vibration, which causes bearing vibration, can be from 3 to 10 times higher than that of bearings."

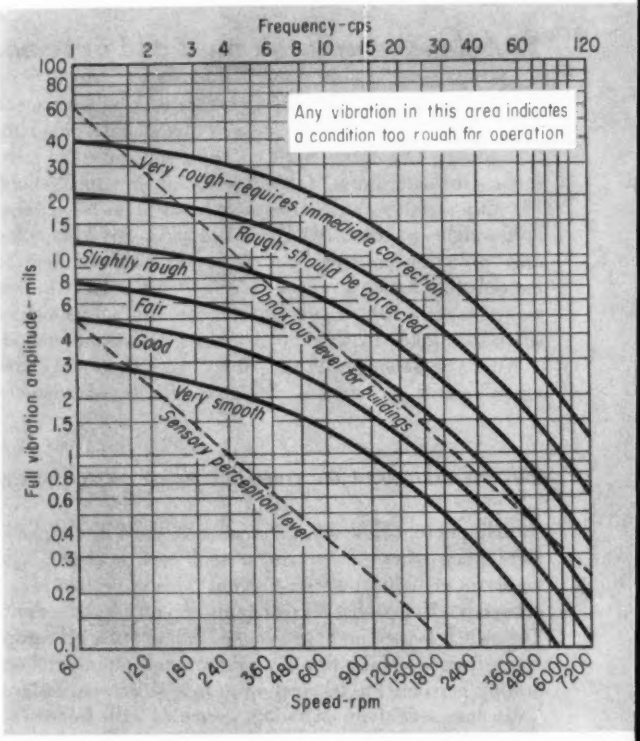
". . . Tom Rathbone of Fidelity & Casualty Co of N. Y. developed the chart, right, that's widely used for bearing measurement. Full amplitude indicated on the ordinate is the double amplitude or peak-to-peak distance from vibrations. This chart is only a guide since tolerances shown are extremely rigid."

". . . Main thing to determine is how much vibration can be tolerated, without harming the machine."

". . . Manufacturers set up vibration limits for their equipment on the test block. But they won't set down limits for vibration in the field. Reason: Type of foundation, alignment of equipment on the foundation and other factors influence readings. So you must consider operation of rotating part and ultimate assembly. If rotor has a high rotational speed, it must be balanced to a high order of accuracy for reasonable bearing life."

". . . If rotor is mounted in a light assembly it must have close tolerances. But if the part is rigidly mounted in a heavy structure, vibration will be absorbed and only bearing life need be considered. Plant engineers often have to establish balancing tolerances on basis of an acceptable noise level. Too, tolerance may be a function of the geometry of the part itself."

The above comments show a great need for vibration standards even though cause of vibration may be from many sources. Regardless of source, the plant man is alerted to the fact that something is wrong. Rather than blame the equipment maker, he should look for misalignment, resonance of floor or mounting, blade wear, dirt, poor lubrication, other trouble sources. This enables him to get optimum use from equipment. Perhaps this report will serve as the first important step to start a meeting of the minds on vibration tolerances in today's industry.


Frequency-cps
1 2 3 4 6 8 10 15 20 30 40 60 120
Any vibration in this area indicates a condition too rough for operation
Very rough—requires immediate correction
Rough—should be corrected
Slightly rough
Objectionable level for buildings
Fair
Good
Very smooth
Sensory perception level
Full vibration amplitude - mils
100 80 60 40 30 20 15 10 8 6 4 3 2 1.5 1 0.8 0.6 0.4 0.3 0.2 0.1
60 120 180 240 360 480 600 900 1200 1500 1800 2400 3600 4800 6000 7200
Speed-rpm

VIBRATION TOLERANCES, above, are for bearing measurement. This chart is only a guide, but will help put you on the right track

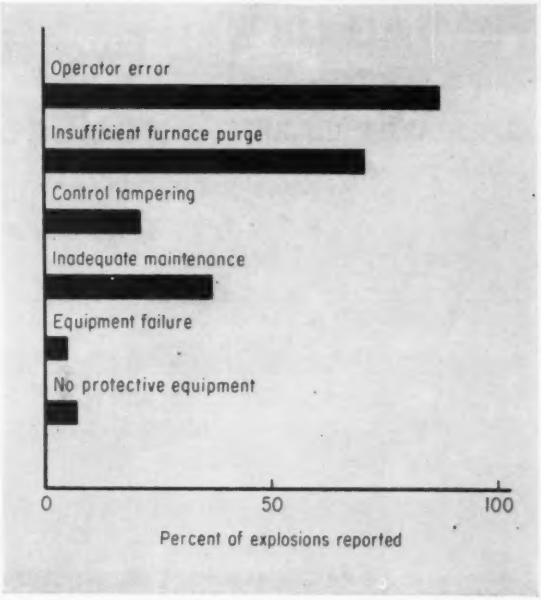
Acknowledgments

POWER is deeply indebted to most of the many manufacturers of balancing equipment for literature, illustrations and technical help. We especially thank the following individuals:

R C Allen, R B Annis, E Berman, D L Bernhard, F Breen, E W Brinkerhoff, R T Buscarello, I E Church, R C Crossley, L Cuckler, E G Dyett Jr, L L Eberhart, S Feldman, A C Flamme, K Frank, L P Grobel, R P Hammone, S B Haney, E Hansen, J V Hendrie Jr, E M Herrmann, E K Irvine, D Kecregioglu, A Kozak, W G Kuensch, A B Langlois, H Law, L Marzetta, E A Massa, W H Moore, H S Mueller, D Muster, T Olsen II, C W Phelps, T C Rathbone, V Roberts, E J Rosecky, M Salvage, D G Stadelbauer, T C Van Degrift, R L Wright

Each year brings an increase in costly boiler explosions. *Power's* accident survey points to one inescapable conclusion . . .

Only you can stop boiler explosions



EXPLOSION SURVEY shows operating error and other human failures as major source. Safe operation demands careful operators

Insurance companies, operators and boiler manufacturers are alarmed by the increase in boiler explosions. Several research programs are aimed at discovering why explosions occur and what can be done to prevent them.

In the meantime, what can you do to avoid furnace explosions in your plant? To help you answer this question, POWER surveyed some rough statistics available from boiler manufacturers and insurance companies. We found a consistent trend in explosion records which definitely showed the main area to concentrate on.

Bar chart, above, shows breakdown of explosion prime causes for 1956-1957, and the same culprit appears at each turn. Human failures contributed to 90% of all explosions we investigated. Various types of human failings accounted for the four largest categories and other minor causes could be traced back to poor judgment as a factor. About 20% of all units reporting explosions had flame-safety equipment, but 92% of these explosions can still be attributed to human error.

Why so much emphasis on human error? A lot of the explosions involved boilers equipped with fully automatic controls and safety systems. How could fully automatic units be affected by so many human errors? The answer to that question is the old story of too little or too much. Too little preventative maintenance and catching of minor troubles before they blow up into big ones; or too much tampering with controls and safety systems.

Our research showed 65% of explosions in fully automated and protected boilers involved unauthorized control adjustment or bypassing. In other words explosions occurred when basic concepts of automation and good operation were ignored. Running with controls or safety devices bypassed is extremely dangerous. In the few cases when you *must* run that way, realize that you are playing with dynamite and take extra precautions.

One type of explosion showed up over and over again. Monday morning startup of oil-fired boilers often can mean trouble with cold oil, so operators bypassed the low oil-temperature switch to get started. Of course, cold oil still gave them trouble, and several attempts to light off deposited oil on furnace walls, floor and roof. Sometime after the unit finally lit, accumulated oil in the furnace vaporized and ignited. Result—a boiler explosion when the operators thought they were fully protected by safety monitors.

What can you do to prevent this sort of accident in your plant? Obvious answer is to cut down on human errors. But to be constructive we must suggest how to do this. Added safety equipment alone will not fill the need. Instead, you must strengthen boiler operator's sense of responsibility. Convince him that safety equipment cannot compensate for poor judgment but *when left alone* it can act as a tool to supplement his actions. If all operators can be convinced that human intervention is potentially dangerous and places added responsibility on them, the bars on POWER's accident chart should wither to stubs.

To complete the story of boiler safety, POWER's July *Today's Developments* report outlines recent design developments and trends in safety systems.

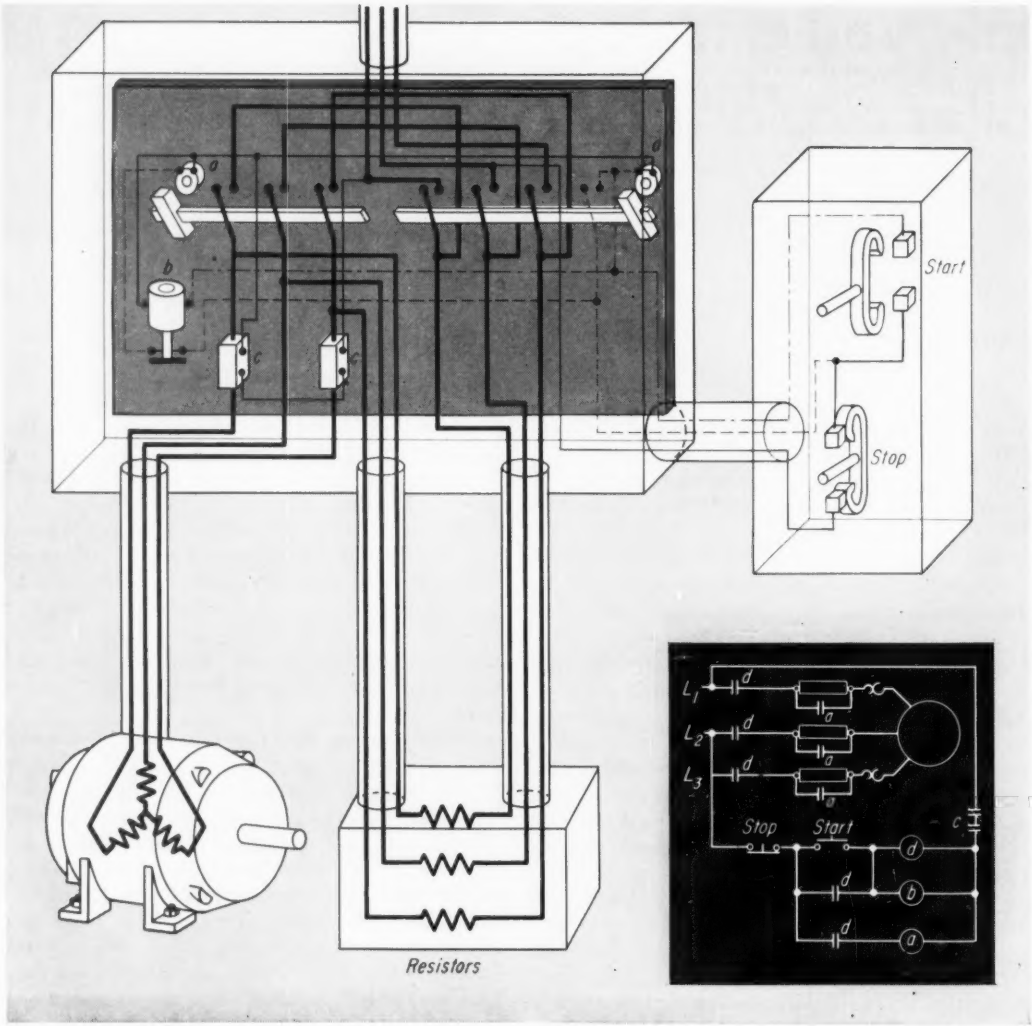
Plant

Electrical Fact File

NO. 37: STARTER CIRCUITS

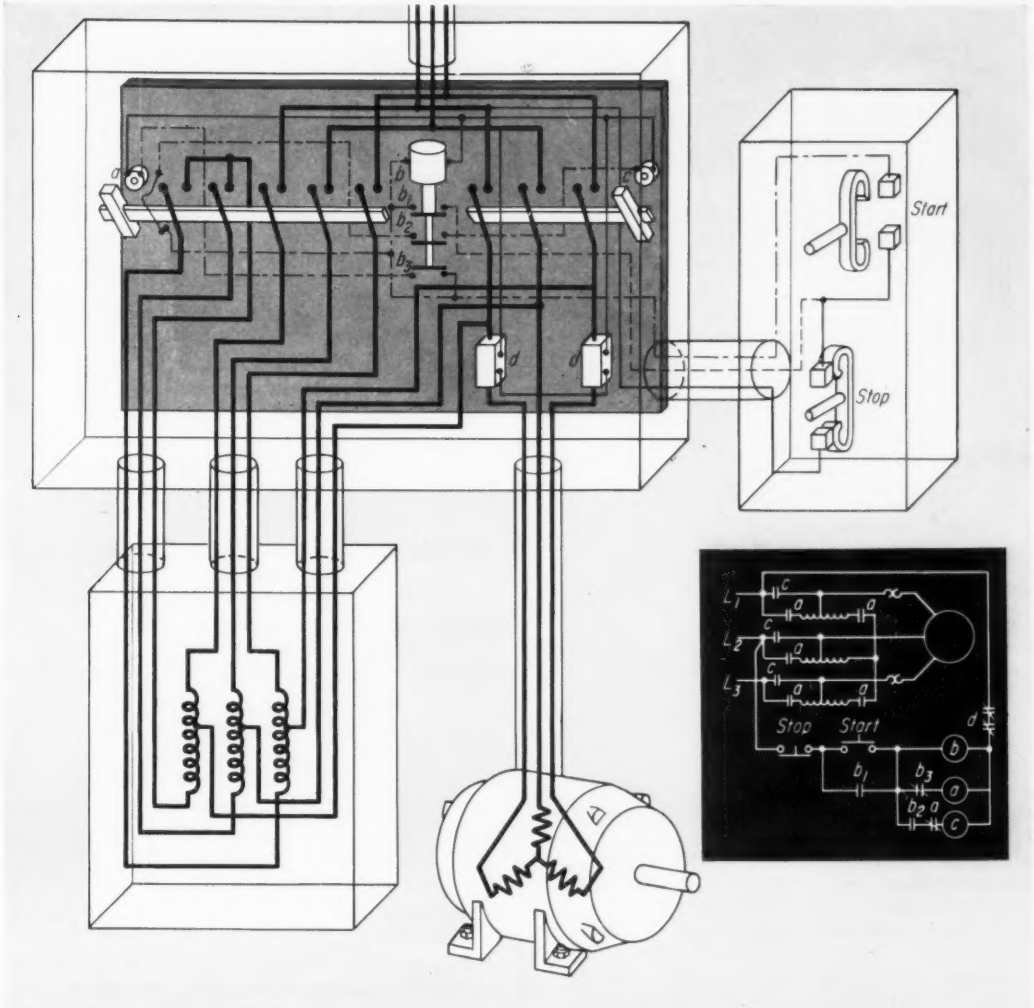
Two circuits for automatic reduced-voltage starting

By NORMAN PEACH, Associate Editor



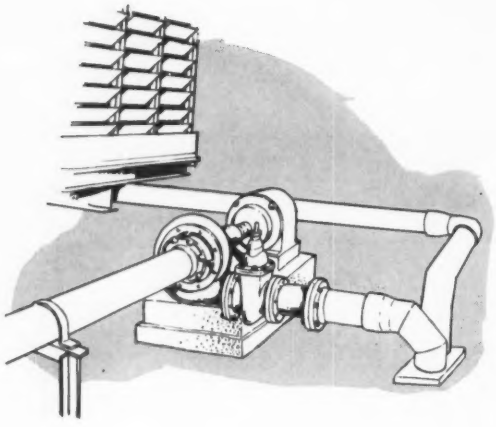
SERIES-RESISTANCE starter has two main contactors. Pushing start button energizes contactor *d* which is held in through its interlock contacts. Timing relay *b* is energized simultaneously and starts to time. Resistance is in series with the motor's stator winding. Relay is set to close its contacts at the time motor has accelerated sufficiently to be connected to line voltage. Contactor *a* then closes, shorting out the resistors. Pushing stop button de-energizes both contactors. Sometimes more than one step of resistance is required; additional contactors and timers are added in sequence. Some controllers utilize a mechanical timer actuated by the contactors. Schematic control diagram for circuit is at right

Several motor-starting schemes limit inrush current, see *Fact File* No. 6, Sept 1956. Two popular hookups for automatic operation are detailed here. Series-resistance scheme is *closed transition;* the circuit stays closed during starting sequence. Starting is smoother, voltage peaks are avoided. Autotransformer scheme is *open transition* (it's possible to get closed transition with a considerably more complicated circuit). Autotransformer limits current more efficiently than does the series resistance.



AUTOTRANSFORMER for one-step starting has three taps which may be selected for 50, 65 and 80% of line voltage. Pushing start button energizes starting contactor *a* through timed contacts *b3*. At same time relay *b* is energized and its instantaneous contacts *b1* keep contactor *a* energized after start button is released. Contactor *a* connects motor to autotransformer taps and closes autotransformer wye. After timing period contacts *b2* close and *b3* open. When contactor *a* drops out its auxiliary contacts close, permitting running contactor *c* to be energized and motor connected directly across the line. Starting circuit must be opened first or there's a short causing circulating current in the autotransformer

These **plant problems** could well be yours...



The problem

Can condensate be used for cooling-tower makeup?

We operate a 2000-ton air-conditioning plant for a large office building. Refrigeration machines are centrifugal type with steam-turbine drive. Our steam is purchased from a public utility and delivered through a 150-psig supply line. In keeping with our policy of cutting down on both water waste and cost, we are considering the use of condensate for makeup water to the cooling towers. At present it's piped to a flash tank and then dumped to the sewer. Is there a possibility that the boiler-water treatment used by the utility will contaminate our recirculating water? I've been told that some plants don't treat their boiler water because the steam is used in company cafeterias for cooking. What experience have other readers had with condensate for this purpose? What are some of the problems involved in making this change?—*FJD, March* POWER

The solutions

Condensate is top-notch makeup supply

FJD's question about using turbine-exhaust condensate for cooling-tower makeup deserves a decidedly affirmative answer. Not only can it be done, but it's already being done successfully in many plants.

There will be far less contamination in condensate from district steam supplied by a large, well-designed public-utility boiler than *FJD* will find in any municipal water supply. Dissolved iron in the condensate might eventually produce some sludge in the cooling-tower basin. But this can be kept to a minimum. Small amounts of carbon dioxide and ammonia will probably be present, but these will be removed by tower's natural degasifying action. Some utilities use amines for corrosion control in district steam lines. These amines will also help combat corrosion in the cooling-water system. In general condensate from turbine-exhaust steam has more than acceptable purity for cooling-tower use.

Add makeup condensate to the tower return line. If its temperature is high enough to produce excessive vapor in the vicinity of the tower, precool by running it through wrought-iron pipe platens located at the air-discharge end of the tower before piping it to return line. *FJD* should use all his condensate for the tower, not just for makeup. Tower blowdown can then be adjusted to keep concentration of solids in the circulating water at the lowest possible level.

F G FEELEY JR, *Larchmont, N. Y.*

Water-treatment control is simplified

A 2000-ton refrigeration system with centrifugal machines will evaporate about 60 gpm of water from the cooling tower at full-load operation. This amounts to a daily total of 86,400 gallons. Let's assume that holding capacity of the system is 40,000 gallons. At startup the concentration of dissolved minerals equals that of raw water used for the initial fill. After 24 hours' operation, if no dissolved solids are removed by blowdown or windage, the system still contains all dissolved minerals originally present. In addition it will contain any dissolved solids present in the 86,400 gallons of makeup water added to replace daily evaporation loss. Concentration of circulating water under these conditions is 3.16 times that of raw water.

In practically all cases blowdown is needed to control circulating-water concentration. Acceptable dissolved-solids level depends on makeup analysis, water temperature, type of chemical treatment used, etc.

If condensate is used for makeup, virtually no dissolved solids are added to system. Theoretically circulating water can concentrate indefinitely. But from a practical standpoint blowdown is still called for to remove dirt and other airborne debris that will enevitably enter the tower.

...Here's how Power readers would tackle them

BOB MARKS, Associate Editor

Chemical treatment for the prevention of scale is certainly not required when condensate is used in the tower. But treatment is still needed to prevent trouble with algae and other slime-forming organisms.

L H CARVER JR, *Kansas City, Kansas*

Cooling-tower makeup needs are slashed

FJD's noncondensing turbine produces about 45-gpm condensate. Evaporation losses from the cooling tower amount to 2%, excluding blowdown. By using this turbine condensate *FJD* can cut total tower makeup by one third. Overall temperature rise of water comes to 3 F, which won't adversely affect refrigerant head pressure.

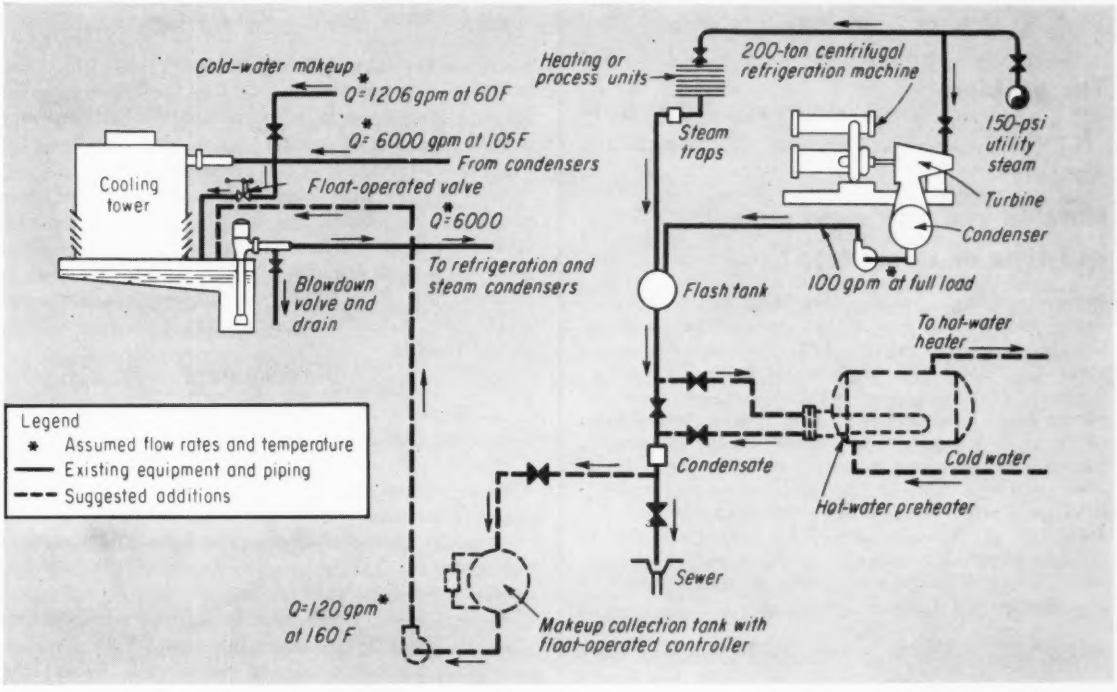
A AWAN, *Brooklyn, N. Y.*

Many plants in our area use condensate

Cooling-tower-condenser systems in the New York City area receive maximum protection from corrosion if we maintain a minimum of 400-ppm chromate or nitrate in recirculated tower water—pH is held between 7 and 8. Use of steam condensate for all or some cooling-tower makeup is a recognized practice for most new installations. With windage drift from tower and temperature rise involved, it's practically impossible to concentrate recirculating water more than 21 times.

Using a mixture of condensate and city supply for makeup keeps total dissolved solids about 25 ppm. Hardness present is then about 0.2 grains per gallon. The pH is in the range of 6.5 to 6.8.

C M STERNE, *Long Island City, N. Y.*



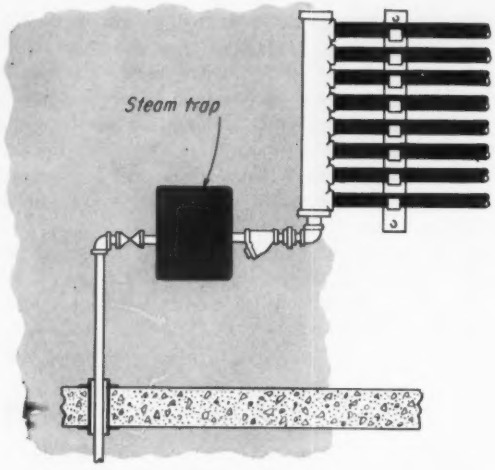
Conversion to condensate calls for collecting tank, pump, controls, piping

Condensate can be used for cooling-system makeup. It can also be used to preheat cold water for general plant use. Flow diagram, above, shows my concept of *FJD's* plant with recommended additions that will make full use of his condensate supply. Quite a bit of piping is called for to collect the condensate and deliver it to the tower. A collection tank with float-operated level control is needed. And another condensate pump will probably have to be added. Carefully check the overall heat balance to make sure that temperature of cooling water will not be seriously affected by heat content of the condensate.

G F CONNELL, *Berkley, Mich.*

Turn page for new problems ►

More **plant problems**



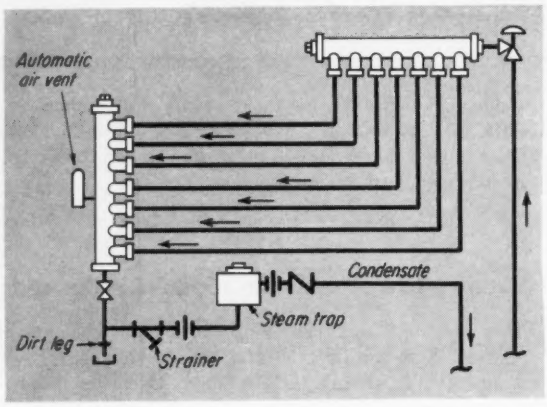
The problem

How do you pick right capacity and type of steam trap?

We are installing a group of shop-built radiators consisting of cast-iron headers and wrought-iron pipe laterals. A typical radiator coil assembly contains about 350 ft of 1½-in. pipe. We estimate that 0.43 lb per hr of 20-psig steam will condense per lineal foot of pipe. Total condensate flow then becomes 350 (0.43) or 150.5 lb per hr. Our problem is to eliminate both air and condensate from each radiator. Does this service call for a trap with large air-handling capacity? If we use a safety factor of three, each trap must handle 450 lb per hr condensate. What capacity should the trap have? What types are best suited for this job? I'd like to hear how other readers handle steam-trap selection.—*WA, March* POWER

Want some help on plant problems? Send us any of your design and operating headaches. We'll put *Power* readers to work on them

The solutions



First estimate the amount of condensate

First step in trap selection is to determine the amount of condensate produced during the warmup period. This can be estimated by using the following formula:

$$Cw = \frac{Pw\ (TR)\ Sm}{L}$$

where Cw is total weight of condensate in lb; Pw is total weight of pipe material in lb; TR is t_1–t_2 when t_1 is temperature of steam at initial pressure and t_2 is temperature of cold pipe; Sm is specific heat of pipe metal and L is latent heat of steam at initial pressure in Btu per lb.

Now let's see how much condensate *WA's* trap must handle. If we assume that his 1½-in. pipe is Schedule 40 with a weight of 2.72 lb per ft, $Pw = 2.72 \times 350$ or 952 lb. When $t_2 = 70$ F and $t_1 = 260$ F (steam at 20 psi) TR becomes 260 – 70 or 190 F. Specific heat of carbon steel is 0.114 (Sm) and latent heat of steam at 20 psi is 938 Btu per lb. Then:

$$Cw = \frac{952\ (190)\ 0.114}{938} = 22 \text{ lb}$$

This is the quantity of condensate formed when bringing pipe coil up to steam temperature from the 70-F level. With a warmup period of five minutes the rate of condensate formation = $22 \times 60 \div 5$ or 264 lb per hr. Since all traps are not rated on the same basis it is good practice to use a safety factor of three. So *WA's* trap must handle 264×3 or 792 lb per hr.

Remember that trap capacity is fixed by differential pressure (inlet minus outlet pressure). Keep backpressure on condensate header to a minimum. When more than one trap discharges into the same header install a check valve between each trap and header. Since condensate rate is greatest during warmup a trap selected on this basis usually handles only condensate formed in normal operation.

An air vent on the radiator coil prevents air binding. Install it where it will vent any air pushed ahead of the steam. Sketch, above, shows one method of doing this. The trap itself should also be able to handle both condensate and air. In addition to a trap for each coil in the system, put one on the end of the steam main.

S R HIGGINS, *Long Beach, Calif.*

Take a careful look at trap capacity

I may have coals of fire heaped on my head for this, but I decry the fetish for oversizing steam traps. Some experts recommend oversizing anywhere from 200 to 500%. This may have advantages in process work where rapid venting and fast heatup is more important than fuel economy. But in a heating system it only results in wiredrawing of trap valve and seat. And steam is wasted as well. In my opinion heating traps should be sized to handle about 125% of maximum capacity. On this basis we cut the capacity of our traps by 50% and as a result save thousands of gallons of fuel oil each year.

WA has seriously overestimated capacity of his coil radiators. Apparently he used a table of heat loss from bare pipe multiplied by 350 ft—figures for bare pipe in still air. Unfortunately, when pipe is stacked, heating capacity is drastically reduced. Warm air from one pipe blankets the pipe above. So actual heat emission of a 1½-in. pipe coil varies with stack height.

Rows	Heat emission	Rows	Heat emission
1	185 Btu/ft*	8	907 Btu/ft
2	348	10	1020
4	616	12	1135
6	793	*Linear ft of coil	

Let's assume the 250 ft of pipe is made into a coil 35 ft long and 10 rows high. Heat output is then 35 × 1020 or 35,700 Btu producing about 40 lb per hr of condensate. Heat output of the stack can be increased by enclosing the coil in a sheet-metal stack open at both top and bottom.

But this type of coil is basically obsolete and inefficient. Why not install a relatively inexpensive blast heater if you need large heat output?

W J Steinert, *Fresh Meadows, N. Y.*

Capacity charts make selection simple

Steam-trap selection is really a simple operation. Capacity charts are readily available for each type of steam trap. These are mostly presented as a function of differential pressure through the trap versus continuous capacity in pounds of condensate for various trap-orifice sizes. *WA* should consider an inverted bucket type trap with a thermic air eliminator and a 3/16-in. orifice diameter. Remember that correct trap installation is just as important as the original trap selection.

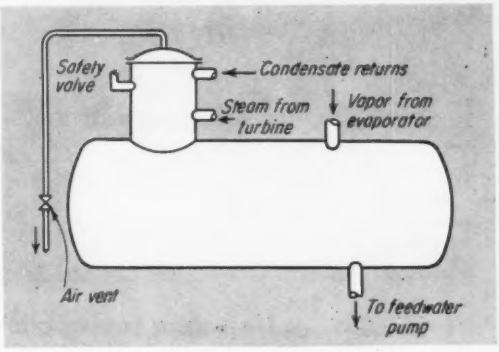
D W Antonacci, *Warrington, Fla.*

Heat output depends on size of coil

Amount of heat given off by a pipe coil depends on the number of pipes in the coil. The more lines of pipe in the coil, the less the heat output per foot of pipe. The *Heating and ventilating guide* states that loss for a single 1½-in. pipe is 185 Btu per linear ft of pipe. Rating for a 10-pipe coil is 1020 Btu per ft of coil with steam at 215 F and air at 70 F. *WA's* installation will work at 260-F steam temperature and probably below 70 F if coils are on the wall near the floor. So output will probably be more than that shown by the *Guide.*

I A Butcher, *Cincinnati, Ohio*

Your June problems



How can we keep air out of our deaerator during shutdown?

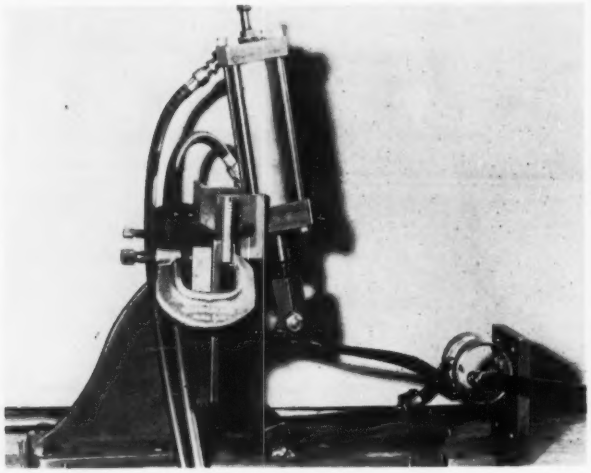
Addition of efficient new generating stations to the system has relegated one of our older power-generating units to the role of peaking operation only. This oldtimer ran smoothly for twenty years. Now many problems arise when we run it as a peaking unit. Oxygen content of the feedwater climbs to 0.5 ppm when the unit starts up, then drops gradually to about 0.07 ppm after four or five hours' operation. When the unit operated continuously oxygen content ranged from 0.02 to 0.04 ppm. Apparently air leaks into the deaerating feedwater heater during shutdown. We are looking for a simple, inexpensive way of keeping air out of this tank. Operating temperature is normally 220 F. What do Power readers suggest?—*YL*

What's the best way to remove fresh-water barnacles?

A serious problem has come up in the operation of our hydroelectric plant. Recent inspection discloses the presence of fresh-water "barnacles" on every piece of steel and iron on the draft tubes and stop-log guides to the intake structure and spillway. The inspection engineer stated that in his many years of experience he has seldom seen a condition as serious as it is here. We want to remove these obstructions and take proper measures to hold any future incrustation to a minimum. Any suggestions or references which Power readers might be able to offer on this problem will be very much appreciated.—*ACK*

Sit down right now and answer one or both problems. We'll pay extra for answers with photos or sketches

Timely **practical ideas** to help solve



Now, new tool applies hose clamps to air lines

Improvising with available equipment, J N Fauver Co, Inc, Detroit made the gadget shown above for fastening hose clamps to air lines. Job is now done four times quicker than when they did it by hand.

Clamps are one-piece O-shaped, having two lugs on opposite sides. Before, clamps were applied by squeezing the parallel sides of the lugs together with a pincers. Now, special tooling, shown, mechanizes use of the pincers, taking the drudgery out of the clamping operation.

A 2-in. diameter air cylinder is used to actuate the clamping tool. Air pressure is set at 40 psi. Tool, welded to the base plate and moving shaft of the air cylinder, is actuated through a 4-way, foot-operated valve. This device has saved a lot of time.

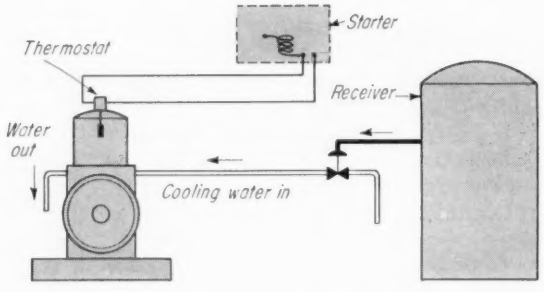
Watch those "dropsy" boys

While closing up a large transformer my helper accidentally dropped one of the ¾-in. cover bolts inside. Knowing a bolt might be lodged between the winding made putting voltage on the transformer unthinkable. Or, to dump 5000 gallons of oil would have been a tough chore.

My helper was fairly sure that the bolt had fallen to the side of the winding, going to the bottom where it could do no harm. However, we couldn't take a chance on guessing.

To remove the bolt from the transformer we made up a heavy permanent magnet from a piece of tool steel. After holding the piece of steel against the pole piece of one of the dc exciters for a few seconds, we lowered it on a cord into the oil. By exploring we finally were able to bring the bolt to the surface.

L McWilliams, *Shawinigan, S, Que.*



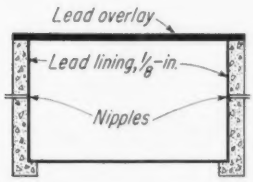
Now our compressor trips before overheating

Sketch shows what we did to prevent our water-cooled compressor from overheating with resulting danger of explosion or expensive overhaul. We installed an air-operated (normally closed) water valve as shown. The diaphragm air valve was piped in from the air receiver. Now when compressor starts the air valve opens and the water supply comes on automatically. As a further preventive measure we installed an adjustable thermostat in the cylinder head of the compressor. This, in turn, was connected through the coil circuit of the compressor starter. Then we preset thermostat to the temperature needed and our compressor now trips when set temperature is exceeded.

V Kitchen, *Arnprior, Ont.*

your tricky design and maintenance problems

STEVE ELONKA, Associate Editor

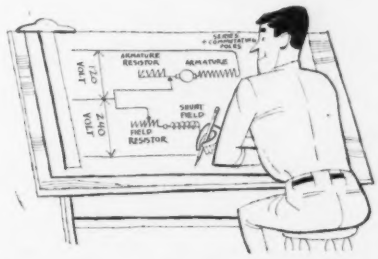


Nipples warn of acid leakage

We recently installed new concrete tanks for our sulfuric acid system. To warn of leakage in the lead lining, we came up with the nipple idea shown in sketch. These are small 3/8-in. brass nipples, cast into the concrete sides of the tanks. They come flush against the lead lining.

When a leak develops in the 1/8-in. lead lining, acid seeps in between the lining and the concrete. First warning is when acid drips from a nipple. When that happens, we connect a hose to the nipple and flush out with water to neutralize the space between the lead lining and the concrete. We then plug one nipple, apply low pressure air to the other. This air stops the acid from leaking and also indicates the exact location of the leak in the lead lining by air bubbles. As soon as the leak is found, we lower the acid level in the tank and make repairs. This idea may have other uses.

H M HUSBAND, *Montreal East, Que.*



What would you have done?

Early one Sunday morning the president of a small manufacturing plant asked me to take a crack at starting his electric blower so they'd have heat on Monday. I suggested that he get an electrician, but he said two of them had monkeyed with the motor for several days without results. So, after agreeing to help, I hustled down to the plant.

I found that the blower was driven by a 20-hp compound dc interpole motor. All wires on the motor and speed regulator were disconnected. So first thing I did was reconnect the motor and speed regulator and start the motor without the blower. From the way it ran and sounded I knew it was electrically and mechanically OK.

Next step was to put the seven V-belts on the pulleys and start the blower. At low speed it sounded like a rock crusher. I stopped the motor, removed the belts and checked the blower for eccentricity, unbalance and alignment. Then I looked at the pulleys. They seemed out of proportion, so I checked the original prints and speed with a tachometer. That blower was traveling way too fast.

Jack shafting or smaller pulleys would have done the trick, but it was Sunday and I couldn't get any. So I split the dc motor for two voltages —240 for field coils, 120 for armature circuit—by bringing the neutral conductor to the motor. When motor was restarted it ran smoothly. A year later I dropped by the plant and found the unit unchanged from the way I'd left it. What would *you* have done?

C BACHMANN, *Jamaica, N. Y.*

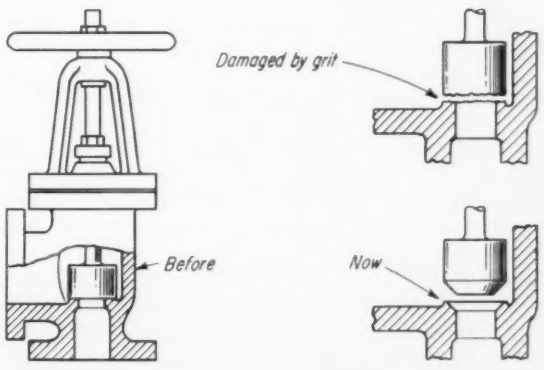
Altered valve seats prevent grit interference

Flat seating-surfaces of lead valves, sketch, used in the chemical process equipment of our plant, acted as grit and dirt accumulation places.

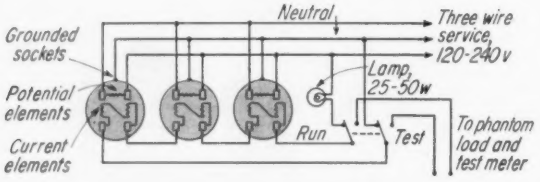
Result of closing these valves on grit and dirt is shown in sketch. In this condition, tight closure was impossible. Valves had to be taken out of the line too often for reseating.

To overcome this trouble we changed from flat to taper seating surfaces. Now, foreign particles cannot hurt the seats because there is no flat surface where they can lodge.

E WITTMANN, *Villas, N. J.*



More **practical ideas**



Do you agree with this way of checking meter standards?

Distance we have to travel to get our meter standards checked at periodic intervals caused a big problem. Our repair shop is located in a northern noble metals installation.

Lacking the needed calibration checks we try to achieve a fair degree of accuracy with three identical standard check meters. The registers are removed from the watt-hour meters before they're installed on the test panel. On meters having the worm wheel separate from the register we disengage the gear from the meter disk. Diagram shows that potential and current coil terminal connections on blade sockets are arranged so both circuits are separated, but with potential leads left connected to top blades.

Current leads are reconnected to the bottom blades. The 3-wire meters have current coils in series to enable current in each to develop forward directional torque. Top jaws of the three meter sockets are connected in parallel, to the correct voltage. All current used is from the same constant current transformer, assuring same potential on the three check meters as in the rotating standard.

We expect to leave the potential on the check watt-hour meters permanently with the current coils of the three check meters connected in series. With the proper array of switches on the bench panel we plan to put current circuit in series with phantom load, plus that of rotating standard.

Double-throw switch is arranged in current circuit. This permits switching the check-meter current over to the supply line and the meters hooked to a constant lamp load ranging from 25 to 50 watts. It's assumed that the slow rotation created by the lamp load will reduce the known tendency of the bearings to become gummed during long idle periods.

Three meters are needed since if only two are used and one unit falls off calibration, the tester would be unaware of the identity of the erring unit. With three in use the tester knows that while one may drift off calibration the other two will be "on the money." Thus the odd meter will be quickly revealed.

How about you fellows in remote areas sending in your ideas on this problem. Unlike a utility with paying customers we are concerned with keeping accurate cost records for the various department electric loads.

In our quest for accuracy we slip badly at times, as when a watt-hour meter of the single-phase 2-wire type was left hanging by its conductors in an upside-down position for a month. Result: zero reading!

W AMMONS, *Clinton, Tenn.*

Make this simple loose connection detector?

A low-voltage test light (flashlight bulb) connected with a low-voltage battery (No. 6 dry cell) makes a good device for indicating loose connections. It also finds resistance too small to be indicated by an ohmmeter. Flashlight bulb requires about 0.25 amp at 1.5 volts, and the operating resistance is, therefore, about 6 ohms. A resistance of 1.5 ohms in series with the light causes a noticeable decrease in its brilliancy. A sudden change of 0.5 ohms will cause a noticeable flicker. This is brought about by imperfect contact between wires and studs on relay contacts. We find this a very handy gadget.

N KHO-RAFANAN, *Cebu City, P. I.*

My biggest boner

Soon after I reported to a ship as a fireman, the first assistant laid down my duties and the watch routine. "Always double check. Don't trust anything you see, and call me if something happens," he snapped.

After raiding the icebox, I went below. First night aboard was quiet. One boiler was donkey, two cut out, only the fuel-oil service pump, fan, one dynamo, the refer, auxiliary condenser and feed pump were running. There would be no changes in the load until morning when we'd cut steam in on the deck for the longshoremen. I had pleasant visions of hitting the sack at midnight.

But came midnight, and no relief. I was stuck for sixteen hours. Time dragged. I made my rounds, switched pumps, changed and cleaned burners and strainers. Finding myself standing under the ventilator, I looked up to check the water—but the glass showed empty.

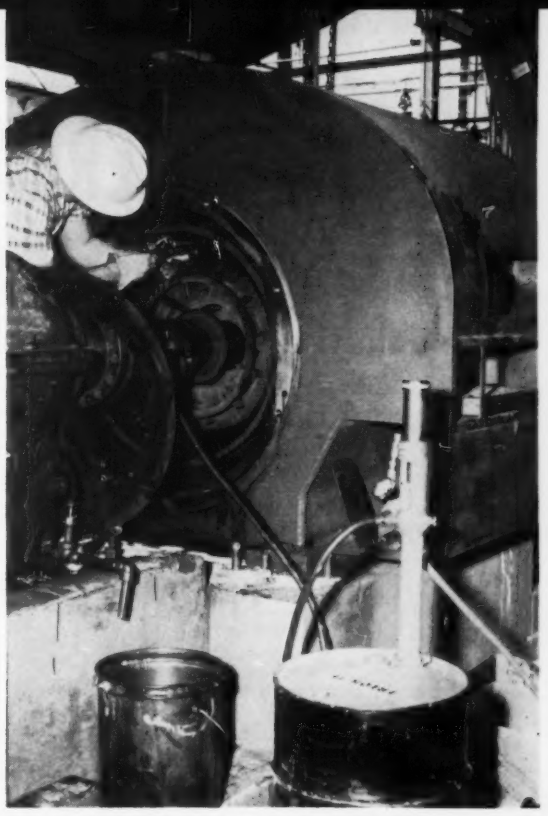
I killed the burners, not daring to speed up the feed pump, and ran up for the first assistant. Dressed only in shorts and slippers he slid down the handrails and landed on the floor plates. I landed on top of him. He dashed for the boiler and blew the water glass. It was full, not empty. Fortunately we didn't lose the plant.

A quick check under the floor plates showed a leaking makeup feed line to the auxiliary condenser. "Shoulda fixed that in Mombassa," grunted the first. "What did I tell you? Never trust anything, always double check," he added. For the rest of my time on that ship the first called me "Double-check." My watch engineer and oiler, never guessing the origin of my nickname, thought it was my family name. Since then, I've avoided many a boner by always double checking.

J KING, *Brighton, Mass.*

Insulations available today start trend back to open motors for many applications and you may want to . . .

Clean your motor windings in place



JET OF SOLVENT at 80-psi pressure is used to remove accumulation of grease, oil and dirt from the stator coils of a 600-hp motor

Motor manufacturers have brought out lines of weather-protected, drip-proof and spash-proof motors which can be used advantageously in many applications where totally enclosed motors were formerly required. These new motors are designed to pick up as little contamination from the ambient air as possible, but in most locations regular cleaning will be necessary, the frequency depending on ambient conditions.

Blowing out motor with an air hose will be sufficient in some cases. In other cases slow buildup of dirt and grease can't be avoided. Trick here is to remove accumulation before it has a chance to harden, and to do it with minimum dismantling. Big economies can be realized where it's practical to clean motors in place, and proper cleaning helps extend coil-insulation life.

Choice of solvent is most important factor. Things to consider are (1) safety—is it fire-resistant and of low toxicity? (2) effect on windings (3) efficiency as a cleaner (4) ease of handling—does it require baking out? (5) cost, which must be weighed against other advantages a solvent may have. Use of jet under pressure rather than air spray has been found to assist solvents in meeting these requirements. Different pumps are on the market for this purpose.

Among solvents to be considered for cleaning in place (naphtha, trichlorethylene, Stoddard's solvent, etc) is a relative newcomer, sold as Freon-TF and otherwise known as trifluorotrichloroethane. It's related to the well-known refrigerant family, but has many advantages as a solvent. It is now being tried out in industry, not only for newer motors, but for cleaning older motors in place. Compared with other solvents cost per gallon is high, but if it makes cleaning in place practicable overall cost may be low.

Safety rating of Freon-TF is high: according to Underwriters' Laboratories report (MH-3072) it is nonexplosive and nonflammable under normal-use conditions. In the lab ignition was not produced until a temperature of 680 C was reached. Toxicity tests conducted by UL indicate that its vapor, with a maximum acceptable concentration (mac) of 1000 ppm, is much less toxic than carbon tetrachloride (mac of 25 ppm) but more than carbon dioxide (mac of 5000 ppm). It's advisable to provide ventilation and avoid prolonged breathing of the vapor. Open flames or heaters can produce toxic decomposition products which are detectable by odor. Freon-TF does not require baking out.

Effects on materials are mild if detectable at all in most cases, according to lab tests. Common metals aren't affected under ordinary conditions. Most insulating materials such as vinyl or acrylic magnet wire coatings, paper, varnished cloth, silicone-treated glass, silicone varnishes and glyptal varnishes are not affected according to extensive tests. Experiments show silicone rubber tends to swell on long exposure. Caution with all rubber-like substances is advisable until more is learned about solvent's effects on these materials.

As an oil and grease solvent Freon-TF is excellent, and oil- or grease-held dirt is readily washed away. Many substances are soluble to different degrees, but sugar and casein are insoluble.

Cleaning method is simply to flush away accumulation with stream of solvent, in all but most stubborn cases. With heavy accumulation preliminary softening and use of stiff brush may be needed. Dirt is easily washed out of air gap and rotor crevices. Freon-TF dries rapidly (it's more volatile than carbon tetrachloride) leaving a clean surface. Even in remote parts of winding, drying is rapid and doesn't require heat. Freon-TF is, of course, an excellent insulator in itself, so accidental residue would do no harm.

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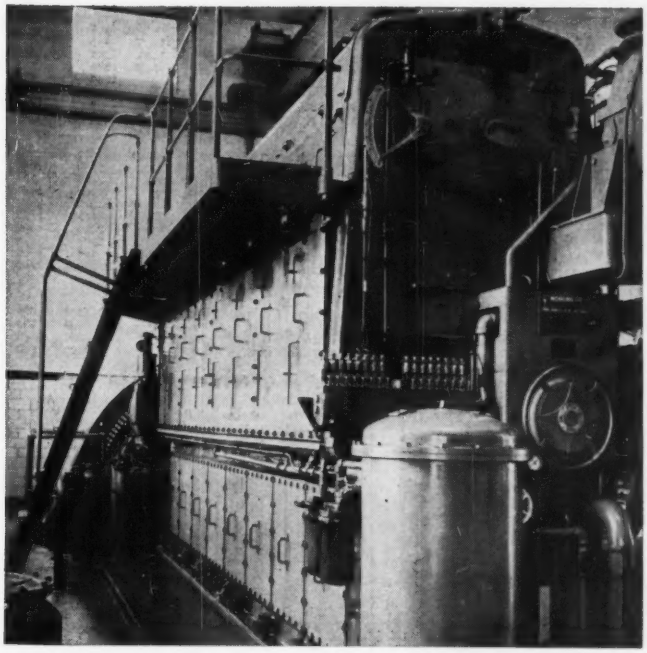

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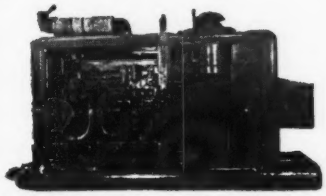

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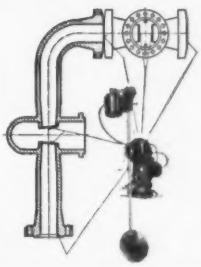

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50 HP Allis Chalmers 1800, 440V
40 HP G.E. 1800 XP Vertical Hollow Shaft
40 HP G.E. 3600 D.P. Vert. Hollow Shaft (5)
30 HP G.E. 3600 D.P. Vert. Hollow Shaft (2)
30 HP West. Type CW 1200 Slip Ring 440V (2)

MISCELLANEOUS

40 Ton OET Crane, 10 Ton Aux.; 47' Span; 75' Lift; Cab Operated
Marley 3-24E-1 Cooling Tower 20,000 GPM
500 KW 120/240 1200 RPM West. Generator
600 Amp G.E. FKO227-50 Oil Breakers (2)
Worthington Deaerating Heater 35,000#/hr
Elliott Deaerating Heater 170,000#/hr
50,000 gal. Water Tower 100' high
16,000 sq. ft. West. Surface Condensers (2)

HEAT & POWER CO. Inc.

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60 East 42nd St., New York 17, N. Y.
310 Thompson Bldg., Tulsa 3, Okla.

ELECTRICAL POWER EQUIPMENT

A. C. MOTORS—3 ph. 60 Cy.

SLIP RING

Qu.	HP	Make	Type	Volts	Speed
1	1750	G.E.	M-579BS	4800/2400	1800
1	1500	G.E.	MT-6	6600	1187
1	800	Whse.	CW	550	1776
1	600	Whse.	CW-432D-15	440	1778
1	500	Whse.	CW	550	350
1	250	G.E.	MT-424Y	4000	257
1	250	Cr. Wh.	SIZE-290	2300	350
1	250	A.C.		550	600
1	250	G.E.	MT-563Y	440	875
1	250	Whse.	CW-1010	2200	435
1	200	Whse.	CW-874D	220	885
1	200	G.E.	IM	2200	580
1	200	G.E.	IM	2300	435
2	200	Whse.	CW-890	2300	1775

SQUIRREL CAGE

1	500	G.E.	FT-359AY	2300	3600
2	550	Whse.	CS-1115	2300	900
4	500	Whse.	CS-1214	2200	500
3	500	G.E.	KF	2300	3600
2	400	Whse.	CS	6600/4000	3565
1	400	G.E.	K-6344Z	440	1185
1	300	Whse.	CS-1002	2300	600
1	200	Whse.	CS-963H	2300	1175/878
1	200	G.E.	KT-587	440	1800
2	200	Whse.	CS-855S	220/440	1750

SYNCHRONOUS

1	7000	G.E.	ATI	2240/6600	600
1	3500	G.E.	TS-6438P	2300/4000	360
2	1750	G.E.	ATI	2300	3600
1	1750	G.E.	TS	2300	900

M-G SETS—3 PH. 60 CY.

Qu.	K.W.	Make	RPM	DC Volts	AC Volts
2	2100/1750	G.E.	514	250/350	2300/4600
1	2000	G.E.	514	600	2300/4600
1	1500	G.E.	720	600	6600/13200
1	1500	G.E.	600	600	2300/4150
1	1200	West.	720	600	2300/4160
1	1000	G.E.	900	260	6600
2	300	G.E.	1200	250	2300
1	500	G.E.	900	125/250	440
1	350	G.E.	900	125	440/4160
1	250	G.E.	900	250	220/440
1	240	West.	900	125	220/440
1	200	El. Mhy	1200	250	2300/4600
1	300	Whse.	1200	600	2300

TURBO GENERATORS

Qu.	KW	Make	Desc.
1	300	G.E.	175/200# Cond. 480/2300 V.
1	1000	G.E.	150# no Cond 2400 V.
1	4000	G.E.	400# surface condenser 2400/4150 volts.

TRANSFORMERS

Qu.	KVA	Make	Type	PH.	Voltages
3	3333	Whse.	OISC	1	13800x2300
3	1000	G.E.	OISC	1	13800x460
2	750	G.E.	PYR.	1	55/255
2	500	Kuhl.	OISC	1	13200x6600
6	333	G.E.	OISC	1	7200/12470Yx2400/4160Y

FREQUENCY CHANGER SETS

Qu.	KW	Make	Freq.	Voltage
3	6750	G.E.	60/25/60	13200/13200
1	5000	G.E.	60/50/60	11000/6600
2	2500	G.E.	25 cy/62.5	2300/2300

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43 Howell St., Jersey City 6, N. J.
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SQUIRREL CAGE MOTORS NEW AND GUARANTEED REBUILT

HP	Make	Type	Speed
500	L.A. B.B. Splash. 440 Volt	FX-1468	3600
500	G.E. S.B. Open	IK	1200
400	L.A. B.B. Splash		1800
400	G.E. S.B. Open	IK	1200
400	West. S.B. Open	CS	900
400	West. S.B. Splash 2300 Volt	CS-30B	720
300	G.E. S.B. Open	IK	1800
300	Ideal—B.B. Splash.	A-1475	900
300	G.E. S.B. Open	IK	900
300	G.E. S.B. Open	IK	720
300	West. S.B. Open	CS-1002	600
300	Reliance. B.B. Splash	AA-8085	600
250	G.E. S.B. Open	KT	1800
250	L.A. B.B. Drip.	OGX-117	1800
250	G.E. S.B. Open 2200 v	IK-18	1200
250	G.E. S.B. Open	IK	1200
250	G.E. S.B. Open	IK	900
250	G.E. S.B. Open	IK	720
200	Cont. T.E.F.C.B.B.	NP-686C	1800
200	West. S.B. Open	CS	1200
200	G.E. S.B. Open	IK-15	1200
200	G.E. S.B. Open	IK-15S	1200
200	G.E. S.B. Open 2200 v	IK	1200
200	G.E. S.B. Open	IK	900
150	West. TEFCBB XP	CS-773.6	3600
150	G.E. TEFCBB	KI6328	3600
150	G.E. TEFCB XP	K	3600
150	Wst. S.S.B. Opn	CS-761C	1800
150	G.E. TEBB	K	1800
150	West. S.B. Open 220V	CS	1800
150	G.E. S.B. Open	IK	1800
150	Marathon. B.B. Drip	TDA-584	1800
150	G.E. B.B. Open	KT	1200
150	G.E. S.B. Open	IK	900
150	Cont. T.E.F.C. B.B. New		900
150	G.E. S.B. Open	KT-558	900
150	G.E. S.B. Open	IK	720
125	G.E. TEFCBB	K	3600
125	A.C. B.B. Open	ARX-505	3600
125	West. T.E.F.C. B.B.	CS-753	1800
125	West. S.S.B. Open New	CS-607	1800
125	G.E. S.B. Open	IK	1800
125	West. S.S.B. Open	CS	1800
125	West. T.E.F.C. B.B.	CS-855	1200
125	Howell B.B. Open	BB-481	1200
125	G.E. S.B. Open	KT-553	1200
125	G.E. S.B. Open	IK	1200
125	G.E. S.B. Open	IK	900
125	G.E. S.B. Open	IK	720
125	G.E. S.B. Open	IK	600
125	West. B.B. Open	CS-874C	600
100	Howell T.E.F.C.B.B.	K-505	3600
100	G.E. B.B. Drip	K-504	3600
100	G.E. S.B. Open	KT-348	1800
100	G.E. B.B. Open	K-504	1800
100	L.A. T.E.F.C.B.B.	JX-113	1800
100	G.E. S.B. Open	KT-347	1200
100	West. SSB Open	CS-807	1200
100	Wagner T.E.F.C.B.B.	CP-635	1200

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4 horizontal, 10 vertical, Westinghouse Driving forced draft blowers—capacities ranging from 39000 to 56000 CFM and 16" to 24" pressure. Steam pressures 360 to 575#, back pressure 10#.

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***Also*—1—250 KW GE turbo generator unit, 3 phase, 60 cycle, 440 volt. Used one year.**

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PUMPS

10 MAIN FEED PUMPS

PUMP: Ingersoll-Rand — size 5" — three stage — capacity 500 GPM @ 750# discharge pressure. B.H.P 330 — 5000 RPM. *TURBINE:* Worthington-Moore — design pressure 575#/sq. inch — non-condensing — back pressure 20# — 5000 RPM — 330 B.H.P.

GEARED TURBINE-DRIVEN MAIN FEED BOOSTER PUMPS

PUMP: Mfg. by Buffalo Pump Co. — vertical single stage — capacity 550 GPM — 30# discharge — 8" suction — 5" discharge. *TURBINE:* 1 stage impulse — type Y-W — vertical — design steam pressure 575# — back pressure 20# — 12.5 HP — 5500/1750 RPM — mfg by Terry Steam Turbine Co.

2 MAIN FEED BOOSTER PUMPS

Same as geared turbine driven main feed booster pumps above, but with 14.5 HP 440/3/60 AC Star motor & Ward Leonard control. Across-the-line starter with pushbutton.

8 GEARED TURBINE-DRIVEN VERTICAL CONDENSATE PUMPS

PUMP: Main condensate 2-stage vertical pump — mfg by Buffalo Pump Co. *Capacity:* 375 GPM — 70#/sq. inch discharge pressure — 1150 RPM — 22.5 BHP — 9" suction — 4" discharge. *TURBINE:* Single stage — 575# working pressure — 20#/sq. inch back pressure — 22.5 HP — 5360/1150 RPM — Mfg. by Terry Turbine Co.

2 AUX. FEED BOOSTER PUMPS

PUMP: Vertical — mfg by Buffalo Pump Co. — 200 GPM — 30# discharge pressure. *MOTOR:* 7.36 HP — 1800 RPM — 440/3/60 — Star motor, with control.

BRONZE RECIPROCATING STANDBY FEED PUMPS

11 x 8 x 18 — mfg by M. T. Davidson Co. — vertical simplex — capacity 180 GPM — 800/900# discharge pressure — 575# working pressure.

4 TURBINE-DRIVEN FIRE AND FLUSHING SERVICE PUMPS

PUMP: Worthington — horizontal centrifugal. *Fire Service:* 750 GPM capacity — 150 PSI discharge pressure — 3500 RPM. *TURBINE:* single impulse — type B-20 — mfg by B. F. Sturtevant — design steam pressure 575# per sq. inch non-condensing. Back pressure 15# — B.H.P. 80/90.

3 GEARED TURBINE-DRIVEN MAIN CIRCULATING PUMPS

PUMP: Mfg. by Worthington Pump & Machinery Co. — 28" type — vertical single stage — bronze. *Capacity:* 28,000 GPM — discharge pressure 13.5# — 600 RPM — 267 BHP — 28" suction — 28" discharge — 8.5:1 gear ratio. *TURBINE:* single impulse — vertical type — 575# design steam pressure non-condensing — back pressure 15#/sq. inch. RPM 5100 pinion — 600 gear. Reduction gear ratio 8.5:1 — 267 BHP — mfg by B. F. Sturtevant.

3 MOTOR DRIVEN MAIN CONDENSATE PUMPS

Mfg. by Buffalo Pump Co. — vertical 2-stage — 375 GPM — 70#/sq. inch discharge pressure — 1150 RPM. *Motor Data:* 25 HP — 440/3/60 — 1150 RPM — Star Electric Motor Co. — with across-the-line starter, with pushbutton station — mfg by Ward Leonard.

8 GEARED TURBINE-DRIVEN MAIN LUBE OIL PUMPS

Mfg. by Northern Pump Co. *PUMP:* Vertical rotary type — 750 GPM — 55#/sq. inch discharge pressure — 263 RPM — 35 BHP — oil viscosity 130 to 500 S.S.U. — 7" suction — 6" discharge. *TURBINE:* Single stage — 575# design pressure non-condensing — exhaust pressure 15# — 35 BHP — 26.39:1 gear ratio — 6940 RPM.

4 TURBINE-DRIVEN GEARED FUEL OIL BOOSTER PUMPS

Mfg. by Northern Pump Co. — vertical rotary — 300 GPM — 150# discharge pressure — 282 RPM — 47.3 BHP — Oil viscosity 70-700 S.S.U. — 7" suction — 5" discharge. *DRIVE:* single stage impulse — 575# non-condensing — 15#/sq. inch discharge pressure.

6 FUEL OIL SERVICE PUMPS

Mfg. by Northern Pump Co. — vertical rotary — 85 GPM — 350# discharge pressure — 560 RPM — 27.4 BHP. *TURBINE:* 1 stage — 575# non-condensing — exhaust pressure 15# — mfg. by Northern.

VALVES

THESE ARE JUST A FEW OF THE MANY VALVES OFFERED. ALL TYPES ARE AVAILABLE INCLUDING REDUCING—SENTINEL—RELIEF—MICROMETER—PRESSURE REGULATING — ANGLE, ETC! STEEL—600# SERVICE—SEND US YOUR REQUIREMENTS FOR QUOTATIONS

LESLIE 2" GOVERNOR VALVES

Type C.P. — class A — capacity 7640#/hr. — 575# steam pressure — 750# discharge pressure.

MOTOR OPERATED GATE VALVES

Low Pressure — comp. geared — 38" — mfg by Chapman Valve Co. *MOTOR DATA:* H.P. 18 ft. lbs. running torque — 45 ft. lbs. max. starting torque — 440 volts 900 RPM 3 phase 60 cycle. Type: Submersible Valve Brake — Motor: Star Electric Co.
Also available, same as listed, but 36", and 28" inch as listed, but with smaller motor.

MISCELLANEOUS

AIR COMPRESSORS AND BLOWERS

18 WIDE RANGE FORCED DRAFT TURBINE-DRIVEN BLOWERS

9 R.H. — 9 L.H. — mfg by B. F. Sturtevant — propeller fan type — capacity 29,500 CFM/5540 RPM/250 BHP — 8250# steam/hr. — and, 9,000 CFM/1985 RPM/9 BHP — 690# steam/hr. — 7 blades — static: max 35" water — normal 21.5" water. Driven by Sturtevant turbine type VC-7 — non-condensing — single stage — 250 HP — 575# steam pressure — 15# PSIG exhaust pressure.

2 HIGH PRESSURE AIR COMPRESSORS, MOTOR DRIVEN THROUGH REDUCTION GEAR

Mfg. by Hardie Tyne — vertical reciprocating type — single acting — 30 cu. ft. @ 3000# discharge pressure — 4 stage — bore 7¾ x 6½ x 2 31/32 x 1½ — stroke 6" — 3 intercoolers — 450 RPM. *MOTOR:* 75 HP — 440/3/60 — 3550 RPM — frame 441 — mfg by GE — class High Shock.

2 LOW PRESSURE AIR COMPRESSORS

Mfg. by Gardner-Denver — vertical tpye — 101 CFM @ 100# discharge pressure — 2 stages — 5¾ x 4¾ bore — 5" stroke — 870 RPM — 25 BHP. *MOTOR:* 28.6 HP — 900 RPM (sync) — 440/3/60 — mfg by Diehl — with Cutler-Hammer control.

LUBE OIL COOLERS

4 — mfg by Westinghouse. 1600 sq. ft. cooling surface — cylindrical straight-tube horizontal type. Oil capacity 590 GPM — water capacity 1500 GPM — temp. oil inlet 150°F — outlet 120°F — temp. water inlet — 85°F — outlet 90°F. Number of ⅝" tubes 816 — Wall 0.049 TK — Cupro-Nickel.

MAIN CONDENSERS

Mfg. by Foster-Wheeler — 23,500 sq. ft. cooling surface — 40,500 GPM circulating water — total tubes 8,976, of cupro-nickel, as follows: (550) each ⅝" x 0.066 and (8416) each ⅝" x 0.049. Monel water boxes.

BOILERS

7 B&W EXPRESS TYPE

Design pressure 634# — operating pressure 565# — temp. 850°F. Oil fired — separately fired superheaters. *Capacity:* 210,000 lb. steam/hr. Ideal for testing where large quantities of steam are required, giving excellent control from separately fired superheaters.

3 GLAND EXHAUST CONDENSERS

Foster-Wheeler — total capacity lbs./hr.: 1200 lbs. steam and 350 lbs. air — 155 sq. ft. — 4" ejector.

LARGE DEAERATING FEED HEATERS

Monel construction — spray type — capacity 480,000 lbs./hr. — vertical condenser — single pass — heating surface 174 sq. ft.

GE HIGH AND LOW PRESSURE MAIN PROPELLING TURBINES

WILL SELL SEPARATELY FOR TESTING, WIND TUNNEL OR SIMILAR WORK. *(2) High pressure* — 24,400 HP — 12 impulse stages — 4909 RPM — working pressure 540# — 825°F. *(2) Low Pressure:* 28,600 HP — 3913 RPM — working pressure 49# steam — 424°F — 2-6 stages of impulse.

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A. C. MOTORS—60 CYCLE

HP	Mfr.	Type	Volts	Speed
800	Whse. (3)	Sq. Cage	2300	1800
750	G.E.	Slipring	2300	514
700	Whse.	Slipring	2300/4000	1200
600	G.E.	Synch.	480	900
600	Elliott (3)	Sq. Cage	2300	900
500	Whse.	Sq. Cage	2300/440	1200
500	Allis Ch.	Slipring	2300/440	600
400	Whse. (2)	Synch.	2300	1800
400	Whse.	Sq. Cage	2200	514
400	Marathon (2)	Sq. Cage	2300	3600
400	G.E.	Slipring	2300	514
350	Br. Boveri b.b.	Sq. Cage	4800/480	720
350	G.E.	Sq. Cage	2200	1800
350	G.E.	Slipring	440	1200
350	Allis Ch.	Slipring	2200/4000	600
350	G.E.	Slipring	220/440	900
300	G.E. (2)	Slipring	2200/440	600
300	Whse.	Slipring	2300	514
300	Whse.	Synch.	440	1200
250	G.E.	Sq. Cage	2200/440	1200
250	G.E.	Sq. Cage	2200/440	450
250	Gen. Elec.	Sq. Cage	440	3600
250	G.E.	Sq. Cage	2200	1800
250	Whse.	Sq. Cage	2300/440	600
200	G.E.	Slipring	220/440	450
200	G.E.	Slipring	440	600
200	L.A. TEFC	Sq. Cage	440	1200
200	G.E.	Slipring	2200	900
200	Reliance b.b.	Sq. Cage	220/440	1800
200	Allis Ch.	Slipring	2300/440	720
200	Whse.	Sq. Cage	2200/440	900
150	G.E. (4)	Slipring	2200/440	600
150	Cr. Wheeler	Sq. Cage	220/440	450
150	G.E. (2)	Sq. Cage	2200.440	1800
150	Whse.	Slipring	220/440	1200
150	G.E.	Sq. Cage	2300	900
125	F.M. b.b. (2)	Sq. Cage	220/440	1800
125	El. Machy. (2)	Synch.	220/440	400
125	G.E. T.E.F.C.	Sq. Cage	2200	3600
125	Al. Ch. TEFC	Sq. Cage	220/440	900
100	Whse. (2)	Sq. Cage	2200/440	720
75	G.E. b.b. (8)	Sq. Cage	220/440	1200

D. C. GENERATORS

KW	Mfr.	Type	Volts	Speed
200	Gen. Elec.	RC	250	1450
150	Whse.	SK-184	250	1150
150	Cr. Wh.	CCD	250	650
75	Gen. Elec.	CD-123	125/250	1200
75	Whse. b.b.	SK-123L	250	1800
60	Ideal	D	125	1150
60	Reliance b.b.	262-T	250	1200
40	Reliance b.b.	230-T	250	1200

D. C. MOTORS

HP	Mfr.	Type	Volts	Speed
250	Cr. Wh.	101-H	230	1150
200	G.E. (2)	RC-38	230	1150
200	Whse. b.b.	SK	550	287/575
150	Rel. TEFC b.b.	2550-F	230	850
150	Whse.	SK-810	230	320/1000
150	G.E. b.b. dyn.	TLC-50	250	1750/3500
125	G.E.	CD-173	230	575/1150
100	Elliott b.b. T.E.	JH-FE	230	1150
80	Whse. dyn. b.b.	SK-123L	250	1800/5000
75	Whse. (4)	SK-163	230	500/1800
60	G.E. TEFC b.b.	CD-135	230	1150
50	G.E. drip b.b.	CD-1445	230	300/1200
50	G.E.	RP-16	230	250/1000
40	Whse. b.b. (2)	SK-163	230	300/1200
25	Whse. (3)	SK-153	230	300/1200

MOTOR-GENERATOR SETS

KW	Mfr.	Input V	Output V
600	Allis Ch.	440 AC	250 DC
300	Whse. (2)	2200/440 AC	250 DC
200	Gen. Elec.*	220/440 AC	125 DC
125	Gen. Elec.*	2300/4000 AC	250 DC
100	Gen. Elec.	220/440 AC	250 DC
75	Star b.b.	220/440 AC	250 DC
75	G.E.	200/440 AC	125 DC
60	Allis Ch.	220/440 AC	250 DC
50	G.E. b.b. (3)	220/440 AC	250 DC
40	Ideal	220/440 AC	250 DC

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(1) 1250 KVA SET

GENERATOR: 1250 KVA Westinghouse Sync.—4600/2300 volt—3 phase—60 cycle—80% PF—A.C.—720 RPM. S.O. 6P-455—complete with 10 KW direct connected exciter. ENGINE: 16 cyl. diesel—16-567 Electromotive Div. G.M.—2 cycle—1440 HP @ 720 RPM.

(1) 1000 KW A.C. SET

Modern 1250 KVA—1000 KW 420/3/50 4-wire diesel set. Alternator direct coupled to generator and mounted on prefabricated base plate. ENGINE: GM 16-278A—serial No. 11691—1700 BHP—16 cyl.—2 cycle—8¾ x 10½—complete with hydraulic governor and overspeed trip. GENERATOR: Mfg. by Electric Machinery Co. —No. 97688—450 volts—3 phase—50 cycles—.8 PF.

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ELGIN 5-5050 — LEXINGTON 9-1900

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150 KW Crocker-Wheeler Motor-Gens. (2) Gens 250V-Motors 3/60-4600/2300V

150 KW General Motors Diesel Units 3/60 220/440V 1800 RPM—(3)

700 KW G.M. 12-567 Diesel Units (4) 3 ph., 60 cycle, 480/2400V

2000 KW GE N.C. Ext. Turbo - Gen. 480V, 600#, 650°, 150# Ext, 30# BP

BREW WOLTMAN & CO., INC.

50 Church Street, New York 7, N. Y.

BOILERS NEW UNASSEMBLED

# Steam/hr.	Key	PSI	Temp.
122,500	DF	565	850
121,650	DF	565	850
60,000	SF	435	750
74,000	H	280	500
55,000	A	240	—

DF Double Furnace, SF Single Furnace (illustrated), bent water tube boilers w/economizers and superheaters, B & W's and Foster Wheelers.

H Header type, straight tube, B & W.

A 3 drum, single furnace, Wickes.

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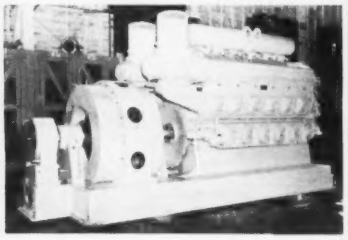
750 KW GM DIESEL ENGINE GENERATOR SETS



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COAL HANDLING EQUIPMENT

Fairfield Eng. Co. 25 ton per hr. unit consisting of R.R. track hopper; reciprocating feeder, 24" x80' belt conveyor, 60' bucket elevator, 100' flight overhead conveyor, 75' overhead 350 ton steel coal bunker, 100' Stock Equip. Co. enclosed drag type under bunker conveyor with 3 triple & 3 intermediate valves.

WATER SOFTENER SYSTEM

Graver 4800 gal. per hr. Deaerating hot process type with Graver spray type raw water heater, pressure filters, chemical tanks, pumps, sludge water & flow meters.

TURBO GENERATOR UNIT

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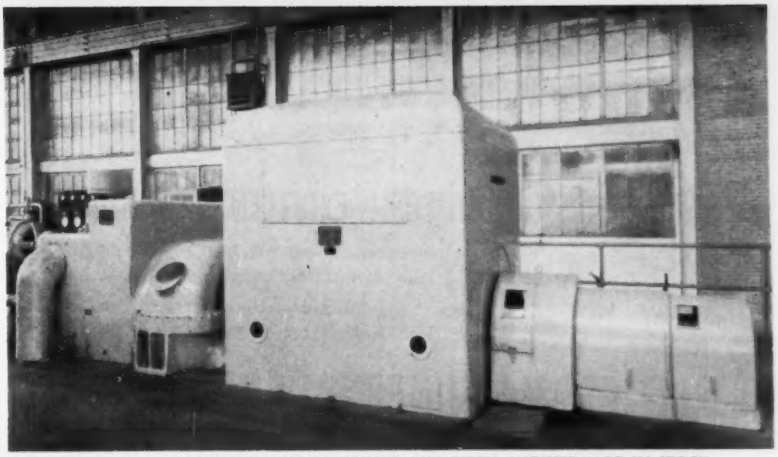

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SQUIRREL CAGE MOTORS
3 phase, 60 cycle, 220 or 440 volts (*2300 volts or higher)

H.P.	MAKE	TYPE	SPEED
1250	*Al.-Ch.	ANX	3600
600	West.	CS	720
600	*G.E.	K-63455	1200
500	*G.E.	K-63455	1200
500	*G.E.	I-13-E	900
350	*G.E.	KT-559-A	1800
300	*G.E.	K6344	1200
250	*W (TE)	CS-81205	1800
250	*G.E.	KT-509-S	1800
250	*West.	CS-875-S	1800
250	Brook	RS28	1200
200	*G.E.	FT-549	3600
200	*G.E.	I-K-13B	1800
200	West.	CSP-581-S	1800
200	Brook	RS-27	1200
200	*West.	CS-930-A	900
200	G.E.	KT-564-S	720
200	*Al.-Ch.	AN-87-G	720
200	*West.	CS-1010	600
200	Al.-Ch.	ARW-631	600
150	Cr-Wh.	SC-140	3600
150	Al.-Ch.	AN 30-F	1200
150	West.	CSP-5815	1200

M.G. SETS

Kilowatt	Make	Volts AC	Volts DC
1000	West.	4000	250
750	G.E.	4160	275
500	West.	440	250
400	Al. Ch.	2300	240
300	West.	2300	250
200	G.E.	2300	275
200	Rdgwy	2300	250
150	Al. Ch.	2300	275
150	West.	2300	250
125	Cr. Wh.	4160	125
125	G.E.	2300	250
100	G.E.	2300	250
100	Al. Ch.	2300	250
60	G.E.	220/440	250
40	G.E.	220/440	250

SLIP RING MOTORS
3 phase, 60 cycle, 220 or 440 volts (*2300 volts or higher)

H.P.	MAKE	TYPE	SPEED
2500	*G.E.	MT (Mill Type)	257
1100	*G.E.	MT	720
1000	*G.E.	M-575-S	1200
1000	*West.	CW	450
600	*G.E.	M-6343-S	1800
500	G.E.	M-6345	1200
400	*G.E.	MTP-585	1200
350	*Al.-Ch.	ARYW	1800
300	Cr-Wh.	SR-76-R	1800
250	Al.-Ch.	ARY-626	1800
250	*G.E.	I-M-17A	720
200	G.E.	I-M-16	600
200	*West.	CW1950A	514
150	Cr-Wh.	SR-50R	1800
150	G.E.	I-M-15A	690
125	G.E.	I-M-15A	600
100	G.E.	I-E-13A	1800
100	G.E.	MT558	720
100	G.E.	I-M-15A	425
75	West.	CW-770	1200

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3—Robinson #13 Sawtooth Crushers, 15 HP

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1—600 KW Al. Ch. Turbo-Gen. 3/60/440, 3600 rpm, non-cond.
1—500 KW El. Mach. Gen. 3/60/440, 327 rpm.
1—150 KW Ridgway M.G. Set, 125V D.C., 440V A.C., 850 rpm.
1—125 KW West. M.G. Set, 125V D.C., 440V A.C. 570 rpm.
75—A.C. motors, 5 to 300 HP.
40—Cleveland, Link Belt Reducers, 1 to 25 HP, ratios 285-1 to 70-1.
12—Transformers 50 and 200 KVA, 2400/440 volts.
1—600 HP Worthington Gas Engine.
1—475 cfm I.R. Comp., Imperial, 200 psi, 125 HP motor.
1—150 cfm I.R. Comp., XRB, twin stage, 175 psi, 30 HP motor.
1—Kerr Steam Turbine, 125 HP, 150 psi, 200 rpm.
1—Moore Steam Turbine, 100 HP, 110 psi.

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1—Clark HMA-4, 165 HP Gas Engine Compressor.
200—Cent. Pumps with explosion proof motor.

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Qu	KVA	Make	Type	Phase	Voltages
2	3000	Moloney	TCR	3	7200/6600-4160/2400
2	750	G.E.	K	1	4600-120/240
3	167	G.E.	HS	1	2400/4160-240/480
1	300	Penna.	(Askarel)	3	12470Y/7200-240
2	250	G.E.	H Pyranol	1	4800/3820Y/120/240
3	250	West.		1	2300/4600-230/460
3	500	West.	SL	1	2400/4160-240/120
3	50	G.E.	H	1	2400/4160-240/120
1	50	Amer.	Abestol	3	4160-120/208Y
4	25	West.	Hypersil	1	2400/4160-120/240
3	75	G.E.	KF	1	2400/4160-120/240
6	25	G.E.	Dry	1	480/240-240/120
3	37½	G.E.	Dry	1	480/240-240/120
3	200	G.E.	HSW2F	1	2400/4160-240/480
3	333	West.	S	1	4150-480/240

MOTOR GENERATOR SETS

Qu	KW	Make	Speed	DC	AC
1	75	EM	1200	250	Syn. 220V.
1	75	G.E.	1200	125	2300/4160 Syn.
2	100	West.	1200	250	2300/4160Y Syn.
1	175	West.	1200	125	4150 Syn.
1	300	G.E.	1200	250	2300/4160Y SR
1	300	G.E.	1200	250	440 Syn.
1	1000	West.	720	600	2300/4160Y

ENGINE GENERATOR SETS

1—Hercules Gas HXE 62.5 KVA Westghe 3/60/480 —1200
1—Wisconsin Gas (Air) PE-99 7.5 KVA Master 1 or 3/120—2200 r.p.m.

SLIP RING MOTORS

Qu	HP	Make	Speed	Type	Volts
2	40	West.	690	CW	220/440
1	60	G.E.	1800	MT	220
1	75	G.E.	600	IM	440
1	100	West.	1800	T.E.F.C. B.B.	220
3	150	Allis-Ch.	1800	AY-RW	2300
1	200	West.	514	CW	440
1	250	West.	600	CW	440
1	350	West.	1800	CW	2300
1	500	G.E.	450	MT	2200
1	500	G.E.	1200	M569Z	2300/4160Y

D.C. MOTORS—230 VOLTS

Qu	HP	Make	Speed	Type
1	92	West.	425/1600	173 FR
1	350	G.E.	1200	Pedestal
1	30	G.E.	1750	SK 113

SQUIRREL CAGE MOTORS, 3 PHASE, 60 CYC.

1—275 HP, 1180 RPM G.E. Type KT 550Bs 2200V
2—200 HP, 1790 RPM, G.E. Elec. KF, TEFC, 2300V
1—150 HP—1130 RPM, West. CS—2300V, Lnst B.B.
1— 75 HP—1200 RPM, West. CS—220/440
1—150 HP, 690 RPM, G.E. KT 562—440 V.

MOTORS—SYNCHRONOUS—3 ph. 60 cy.

100 HP 900 RPM G.E. Fom BL 2200 V.
125 HP 600 RPM G.E. Type TS 2200 V.
125 HP 900 RPM G.E. Type TS 4800 V.
150 HP 1800 RPM G.E. Type TS 220 V.
325 HP 900 RPM West—2300 V.
300 HP 720 RPM Elec. Machinery t.e.f.c. 2300 V.
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H.P.	Volts	Make	Speed
500	4000/2300	G.E.	600
400	2300	G.E.	900
400	4000/2300	Whse.	720
300	4000/2300	G.E.	720
300	2300	G.E.	900
300	440	G.E. (hoist)	600
300	440	Whse.	3600
225	4000/2300	G.E. (hoist)	600
200	2300	G.E.	600
200	2200/440	G.E.	720
150	220/440	Whse.	720
125	2300	G.E.	600

AC GENERATORS or SYN MOTORS, 60 Cy.

H.P.	Volts	Make	Type	R.P.M.
400	2200/440	G.E.	ATI	720
300	440/220	G.E.	TS	450
300	2200/440	G.E.	TS	1200
200	2300/440	Whse.	G	1200
150	440/220	Whse.	G	1200
125	440/220	Whse.	HR	400

SQUIRREL CAGE MOTORS

500	2200/4000	Elliott	SC	1800
400	2300	G.E.	FT	3600
400	2300/4000	G.E.	K	1200
350	2300/4000	G.E.	SEDP	3600
350	2300/4000	G.E.	K	600
300(2)	2300	G.E.	FT	3600
300	2300/4000	L. Allis.	FS	1800
300	2300/440	G.E.	SEDP	1200
300	2300/4000	Cont'l.	Spl-Prf.	720
300	2300/400	G.E.	KT	600
250	2300/4000	G.E.	K	720
200	2200	G.E.	KT	1800
200	2200	Cont.	TEFC	3600
200	440/220	G.E.	KT	720
150	440	Whse.	X-pf.	3600
150	440/220	Cont'l.	X-pf.	1800
150	440/220	G.E.	TEFC	720
150	2200/440		KT	600
150	2200/440	G.E.	FT	1200
125	2200/440	G.E.	K	600
100(2)	4000/2300	L. Allis	OX	1200
100	2300	Cont'l.	TEFC	3600
60(2)	440	Cont'l.	X-pf.	1800

CIRCUIT BREAKERS, 3 Pole

4—1600 Amp., DA-50, Whse., 600 V., Air
1— 600 Amp., Al. Chal., 15 KV, Outdoor
6— 600 Amp., R. Smith, 7.5 KV, Sol. oper.
1— 400 Amp., R. Smith, 7.5 KV, outdoor, New

D. C. MOTORS

H.P.	Volts	Make	Type	Speed
150	230	El. Dyn.	B/brg.	600
125	230	G.E.	CD	600
50/60	230	Rel.	T	600/1800
50	230	G.E.(4)	CD	1150

MOTOR GENERATOR SETS

KW	Make	Input., AC	Motor Type	Output V., DC
300	Whse.	4150/400	Syn.	250/125
250	Whse.	440	Syn.	250
125	G.E.	440/220	Sq. Ca.	125
125	G.E.	440	Sq. Ca.	250/125
100	G.E.	2200/440	Syn.	250
75	Cr. Wh.	440/220	Sq. Ca.	240/120
70	El. Dyn.	440	Sq. Ca.	70
65	G. E. B	2200/440	Sq. Ca.	250

TRANSFORMERS 60 Cy.

1—500 kva, Al. Ch. 2400/4160Y—600 volts, 3 ph.
3—500 kva, G.E., 13800—2300 V.
3—500 kva, G.E., 13800—240/480 V.
3—500 kva, G.E., 2400—240/480 V.
3—333 kva, American, 2400—240/120 V.
1—200 kva, G.E., 2400—120/240 V., Pyr.
3—200 kva, Mol., 13,800—2300 V.
3—200 kva, G.E., 13,800—480 V.
3—200 kva, G.E., 4156—480/240 V.
3—167 kva, Whse., 4156—480 V.
3—150 kva, Al. Ch., 2400—220 V.
3—150 kva, G.E., 13,200—2300 V.
3—100 kva, Whse., 4800/2400-240/480 V., Dry
3—100 kva, G.E. 2400—120/240 V., Pyr.

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2—35 kva, 900 R, 220 V, 3 ph. con. LeRoi, 6 cyl.

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New 1949 — Excellent condition

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1—1000 KW Allis-Ch. 3-60-480V Non-con, 15#s B.P.
1—750 KW West. 3-60-4160V Auto-ext. 15#s
1—600 KW West. 3-60-4160V Auto-ext. 15#s
2—500 KW Allis-Ch. 3-60-440V Non-con, 15#s B.P.
1—400 KW Terry 3-60-440V Non-con, 15#s B.P.
2—250 KW Skinner engines 3-60-2300V

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1—300, 1—200 KVA, 3/60/4160-240 Wagners, ITE type HPS Outdoor Unit Substations.
2—250 KVA, 1/60/2400-240/480 Moloney, OISC, type YC, W/taps.
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1—200 KVA Wag. 1/60/2300-115/230
3—100 KVA 1/60/4160-240/480 Packard OISC
3—25 KVA, WHSE. 1/60/2400—240/480 OISC.
2—50, 6—37½ KVA, G.E. 1/60/2400-120/240 OISC.

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[4] 1000 KW GEARED TURBO-GENERATORS

For Condensing or Non-Condensing

1000 KW TURBO-GENERATOR COMPLETE WITH CONDENSERS CIRCULATING PUMPS CONDENSATE PUMPS AND SWITCH GEAR

GENERATOR: 1000 KW—type ATB-2—G.E.—form H.L.—1250 KVA—3/60/450—1605 amps—3600 RPM—0.8 P.F.—field amps 87—typical serial No. 5358205—with 120 volt 11KW DC exciter—compound wound.

STEAM TURBINE: 1000 KW G.E.—type FSN-4R-FN30-85TG—rated 7964 RPM—exhaust 1 lb. absolute when condensing.

REDUCTION GEAR: S-118—form A—RPM 7964/3000.

TURBINE STEAM PRESSURE: 375 lbs—175°F superheat-exhaust pressure 1 lb. absolute when condensing. Can be used condensing or non-condensing.

BUILT AS MARINE UNITS USING FINEST MATERIALS. DRIP - PROOF CONSTRUCTION. UNITS ARE 16' LONG—7'8½" WIDE. MOUNTED ON PRE-FAB SUB-BASE.

OPERATING CONDITIONS

1. The turbines are designed for normal operation condensing at 375 lb per sq in gauge, 175°F superheat steam at throttle, and 1 lb. per sq. in. absolute at the turbine exhaust flange.
2. The turbines will operate successfully condensing at 375 lb. per sq. in gauge, 0°F superheat at throttle, and 1 lb. per sq. in. absolute back pressure at the turbine exhaust flange.
3. The units have an overload capacity of 25% (1250 KW, 0.80 p-f) for two hours with normal main and exhaust pressures.
4. The units have an overload capacity of 50% (1500 KW, 0.80 p-f) for five minutes with normal main and exhaust pressures.
5. The units will deliver normal output (1000 KW, 0.80 p-f) with main pressure 20% below normal and with a back pressure of 2 lb. per sq. in. absolute at the turbine exhaust flange.
6. The turbines will operate successfully with a maximum main pressure of 450 lb. per sq. in. gauge and with a maximum superheat of 200°F at the throttle.
7. The turbines will develop 500 KW with 375 lb. per sq. in. gauge, 175°F superheat steam at throttle, and 29 lb. per sq. in. gauge back pressure at the turbine exhaust flange.
8. The turbines will operate successfully when extracting steam from the second-stage shell of the turbine. An automatic pressure regulating valve and a non-return valve should be installed in the extraction line to hold the extraction steam at approximately 10 lb. gauge and to prevent a return flow of steam to the turbine.
9. The turbines will operate successfully with full steam flow to atmosphere.
10. The units will cover the entire range of conditions as listed above under automatic control of the speed governor.
11. The steam flow to the throttle is guaranteed not to exceed the amounts listed in Part V for the given loads when operating with steam at 375 lb. per sq. in. gauge at throttle, 175°F superheat, and 1 lb. per sq. in. absolute at the turbine exhaust flange. The guaranteed steam flows include the necessary steam for sealing the packing glands, and includes the electrical losses for the exciter fields and rheostats.

THE BOSTON METALS CO.
313 E. Baltimore St. Baltimore 2, Md.
ELGIN 5-5050 LEXINGTON 9-1900

Advertisers' Index

A

ACF Industries, Inc. W-K-M Division ..... *
Air Preheater Corp. 109
Allen-Sherman-Hoff Co. ..... *
Allgemeine Elektricitats-Gesellschaft ..... Second Cover
Allis-Chalmers Mfg. Co. 145, 147, 149, 151
Allis-Chalmers Mfg. Co., Hydraulic Div. ..... *
Allpax Company, Inc. ..... *
Alpha-Molykote Corp. 137
American Brass Co. 189
American Engrg. Co. 207
American Gilsonite 205
American Hard Rubber Co. ..... *
American Meter Co., Pump Div. ..... *
American Pulverizer Co. 144
American Standard Industrial Div. 48-49
Ames Iron Works ..... *
Anchor Packing Co. 173
Annin Company ..... *
Armstrong Machine Works 101
Atomics International Div. of North American Aviation 164

B

B-I-F Industries, Inc. 116
Babbitt Steam Specialty Co. 190
Babcock & Wilcox Co. Boiler Div. 4-5, 107
Babcock & Wilcox Co. Tubular Products Div. 61
Badger Mfg. Co. 20
Bailey Meter Company 10-11
Baldwin-Hill Co. ..... *
Baltimore & Ohio Railroad ..... *
Barnes & Jones, Inc. 196
Basnik Co., Vince 190
Belmont Packing & Rubber Co. ..... *
Biddle Co., James G. ..... *
Bingham Pump Co. 191
Bituminous Coal Institute ..... *
Black, Sivalls & Bryson, Inc. 175
Blaw-Knox Company Equipment Div. 212D
Blaw-Knox Company Power Piping Div. ..... *
Boiler Tube Co. of America ..... *
Bonney Forge & Tool Works 154
Borg-Warner Mechanical Seals Div. of Borg-Warner Corp. 182
Bridgeport Brass Co. 115
Brown Boveri Corp. 62
Buell Engineering Co. 134
Buensod-Stacey Co. ..... *
Buffalo Forge Co. 24-25
Buffalo Pumps, Inc. ..... *
Bussmann Mfg. Div. 68-69
Butler Mfg. Company 40

C

Capitol Pipe & Steel Products, Inc. 65
Carpenter Steel Co. Alloy Tube Div. 44-45
Catawissa Valve & Fittings Co. ..... *
Centrifix Corp. ..... *
Chase Brass & Copper Co. 63
Chemtrol ..... *
Chesterton Co., A. W. 194
Chicago Pneumatic Tool Co. 26-27
Childers Mfg. Co. ..... *
Clarage Fan Co. 66
Clark Bros. Co. One of the Dresser Industries ..... *
Cleaver-Brooks Co., Boiler Div. 158
Cochrane Corporation 195
Coen Company ..... *
Combustion Engineering, Inc. 46-47
Condenser Service & Engrg. Co. ..... *
Cooper-Bessemer Corp. 34-35
Copes-Vulcan Div., Blaw-Knox Company 12-13
Coppus Engineering Corp. 113
Corning Glass Works ..... *
Crane Company 139
Crane Packing Co. 188
Crawford Fitting Co. 162-163

D

Dearborn Chemical Co. ..... *
DeLaval Steam Turbine Co. 14-15
Detroit Controls Div. of Amer. Standard ..... *
Detroit Stoker Co. 193
Diamond Power Specialty Corp. 6-7, 171
Dodge Mfg. Corp. ..... *
Dow Chemical Co. ..... *
Dow Corning Corp. ..... *
Dowell ..... *
Dustex Corp. ..... *

E

Engle-Picher Co. 120
Edward Valves, Inc. 18-19
Electrama ..... *
Electric Machinery Mfg. Co. ..... *
Elgin Softener Corp. ..... *
Elliott Company 50-51
Elliott Company—Lagonda Plant 184
Elliott Company—Roto Plant 148
Emhart Mfg. Company Maxim Div. ..... *
Engineer Company ..... *
Erie City Iron Works 30-31

F

Fairbanks Company 152, 180
Fibreboard Paper Products Corp. Pabco Ind. Insulations Div. ..... *
Fisher Governor Co. 121
Flexitallic Gasket Co. ..... *
Fly Ash Arrestor Corp. ..... *
Foster Company, Benjamin ..... *
Foster Wheeler Corp. 122-123
Foxboro Company 133
Frick Company ..... *
Fuller Company ..... *

G

Garlock Packing Company 199
General Controls Corp. ..... *
General Electric Co. 36
Goulds Pumps, Inc. ..... *
Green Fuel Economizer Co. 37
Grinnell Company 167
Griscom-Russell Co. 52

H

Hagan Chemical & Controls, Inc. 64
Hall Laboratories ..... *
Hamon, Inc. ..... *
Harbison-Walker Refractories Co. ..... *
Hartman-Walsh ..... *
Heyl & Patterson, Inc. ..... *
Hungerford & Terry, Inc. 146

I

I-T-E Circuit Breaker Co. 57-58-59-60
Illinois Water Treatment Co. ..... *
Infilco Inc. 155
Ingersoll-Rand Co. 21
International Boiler Works Co. 166
International Nickel Co., Inc. 153
International Register Co. Instrument Div. 136
Iron Fireman Mfg. Co. ..... *

J

Jenkins Bros. 103
Jerguson Gage & Valve Co. 176
Johns-Manville 16-17
Johnson Service Co. 108

K

Kato Engineering Co. ..... *
Keasbey & Mattison Co. 208
Keeler Co., E. ..... *
Kennedy Valve Mfg. Co. 192
Kennedy-Van Saun Mfg. & Engrg. Corp. 56
Kerrigan Iron Works, Inc. ..... *
Kieley & Mueller, Inc. 29
Kinney Engineers, Inc., S. P. 176
Kirk & Blum Mfg. Co. ..... *
Klipfel Valves, Inc. ..... *
Koppers Co., Inc. Coupling Dept. ..... *
Koppers Co., Inc. Electrostatic Precipitators ..... *

L

Laclede Stoker Co. ..... *
Ladish Company ..... *
Leslie Company 54-55
Limitorque Corp. 203
Link-Belt Company 1
Liquidometer Corp. ..... *
Lunkenheimer Co. ..... *

M

Manning, Maxwell & Moore ..... 106, Third Cover
Marley Company 117
Marsh Corp., Jas. P. ..... *
Mason-Neilan Div. of Worthington Corp. ..... *
McDonnell & Miller, Inc. 204
McGraw-Hill Book Co. ..... *
McNally Pittsburg Mfg. Corp. 200
Mercoid Company ..... *
Midwest Piping Co., Inc. ..... *
Minneapolis-Honeywell 211
Monsanto Chemical Co. Organic Chemical Div. 172
Morton Salt Co. Industrial Div. ..... *
Murray Iron Works Co. 124
Murray Mfg. Co., D. J. 53

N

Nalco Chemical Co. 97
National Airoil Burner Co., Inc. ..... *
National Conveyors Co., Inc. ..... *
National Electric Coil 260
National Tube Div. of U. S. Steel 104

This index is a service to readers. Every effort is made to maintain its accuracy, but POWER cannot assume responsibility for errors or omissions. When a star appears after the name, the advertisement does not appear in this issue but appeared in an issue within the previous three months.

Niagara Blower Co. ... *
Nicholson & Co., W. H. ... 157
Nordberg Mfg. Co. ... 212C
Norfolk & Western Railway ... *

O

Ohio Brass Company ... *

P

Panellit, Inc. ... *
Patterson-Kelley Co. ... *
Peabody Engrg. Corp. ... *
Peerless Pump Div., Food Machy. & Chemical Corp. ... *
Pennsylvania Pump & Compressor Co. ... 202
Pfaudler Permutit, Inc. ... 114
Phelps-Dodge Copper Products Corp. ... 70
Philadelphia Gear Corp. ... 203
Phoenix Mfg. Co. ... 185
Pioneer Service & Engineering Co. ... 160
Pipe Fabrication Institute ... *
Pittsburgh Piping & Equipment Co. ... *
Porter Co., Inc., H. K. Forge & Porter Fittings Div. ... 150
Powell Co., Wm. ... 22-23
Pratt Co., Henry ... *
Pritchard & Co., J. F. ... *

R

R-P & C Valve Div., Amer. Chain & Cable Co., Inc. ... 198
Raybestos-Manhattan, Inc. Manhattan Rubber Div. ... *
Raybestos-Manhattan, Inc. Packing Div. ... 178
Reliance Gauge Column Co. ... *
Republic Flow Meters Co. ... 183
Republic Steel Corp. Steel & Tubes Div. ... 118-119
Research-Cottrell, Inc. ... 42-43
Ridge Tool Company ... 132
Riley Stoker Corporation ... 94-95
Robertshaw-Fulton Controls Co. Aeronautical & Instrument Div. ... 180
Rockwell Mfg. Co. Nordstrom Valve Div. ... 131
Rohm & Haas Co. ... 161

S

Sarco Company, Inc. ... 201
Schaub Engrg. Co., Fred H. ... 206
Schoonmaker Co., Inc. A. G. ... *
Scovill Mfg. Co. ... *
Smith Corp., A. O. ... 166
Socony Mobil Oil Co. ... 38-39
Sparkler Mfg. Co. ... *
Spence Engrg. Co. ... 179
Standard Oil Co. of Indiana ... 105
Stephens-Adamson Mfg. Co. ... *
Stickle Steam Specialties Co. ... 190
Stow Mfg. Co. ... *
Strong, Carlisle & Hammond ... 112
Superior Combustion Industries, Inc. ... 143

T

Terry Steam Turbine Co. ... 32
Texas Company ... *
Titusville iron Works Co. Div. of Struthers-Wells ... *

U

Union Asbestos & Rubber Co. ... 159
Union Iron Works ... *
U. S. Electrical Motors, Inc. ... *
United States Gauge ... 212B
United States Motors Corp. ... *
Universal Atlas Cement Div. of U. S. Steel ... 28

V

Viking Pump Co. ... *
Virginia Gear & Machine Corp. ... *
Vogt Machine Company, Henry ... 41

W

Wallace & Tiernan, Inc. ... 130
Walworth Company ... 209
Western Chemical Co. ... *
Western Precipitation Corp. ... 197
Westinghouse Electric Corp. ... 99, 135, 177
Wheeler Mfg. Co., C. H. ... 129
Where to Buy ... 249
Whiton Machine Company ... 156
Wickes Boiler Co. ... 181
Wiedeke Co., Gustav ... *
Wolverine Tube Div. of Calumet & Hecla, Inc. ... 165
Worthington Corp. ... Back Cover

Y

Yarnall-Waring Company ... 8-9, 33, 146

Z

Zallea Brothers ... *
Ziegler Co., G. S. ... *
Zimmerman Packing Co. ... 176

Professional Services ... 249

CLASSIFIED ADVERTISING

F. J. Eberle, Business Mgr.

EMPLOYMENT OPPORTUNITIES ... 250

BUSINESS OPPORTUNITIES ... 250, 251

EQUIPMENT
(Used or Surplus New) For Sale ... 251-257

WANTED
Equipment ... 256

ADVERTISERS INDEX

A. & L. Z. Properties Company ... 254
Ajax Electric Motor Company ... 256
Alco Products Inc. ... 250
Allied Electric & Machinery Company ... 256
American Air Compressor Corp. ... 255
Arg Chemical Machinery ... 256

Belyea Company Inc. ... 252
Benson-Wilimzig Inc. ... 257
Boston Metals Company, The ... 251, 253, 254, 256, 257
Brill Equipment Company ... 255, 256
Brew-Woltman & Company Inc. ... 254

Campbell Electric Company ... 255
Chicago Electric Company ... 255

DeRose G. M. ... 252

Hauerwas, August ... 251
Hewitt-Robins Inc. ... 254
H & P Machinery Company ... 255
Heat & Power Company Inc. ... 252
Hall & Company, Stephen ... 257
Hemphill & Company J. L. ... 256
Hughes Company Arnold ... 257

International Power Machinery Co. ... 257

Land Inc., L. J. ... 257

Mertium Corp. ... 256
Midwest Boiler & Turbine Co. ... 257

Pelnik-Loconti Industrial Supply Co. ... 254
Perry Equipment Corporation ... 255
Power Equipment Company ... 252

Sargent & Lundy ... 250
Schoonmaker Company Inc. A. G. ... 254, 256
Ship Supply Corp. ... 256

Universal Power & Engineering Co. ... 254
Utilities Machinery Corp. ... 251, 256

Wagner Company, Arthur ... 254
Weaver Inc. Charles ... 255
Whistler Equipment Company ... 255

National tailor-makes the coil to fit your application

These generator stator coils symbolize the full range of coil insulations offered by National Electric Coil. Since NATIONAL either *makes or uses all types* of insulation, our recommendations are based solely on the requirements of your application.

Here's the range of insulation systems NATIONAL offers:

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- Mica and glass combinations impregnated with catalytic type resins such as epoxies, polyesters and blends.
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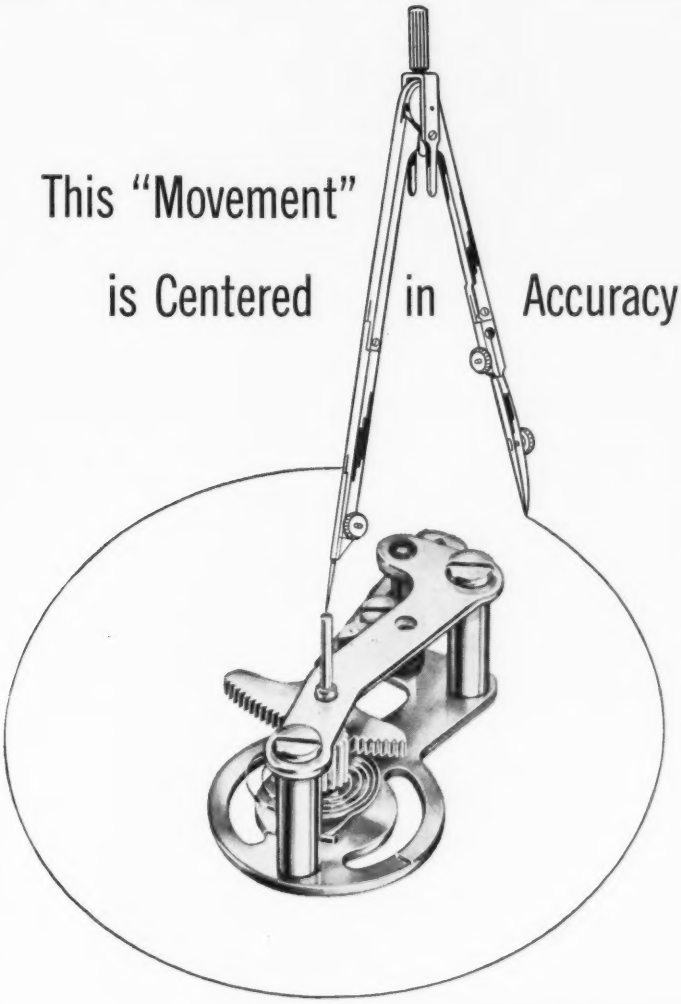

The rotary movement in Ashcroft Duragauges has a geared center shaft on which the pointer is mounted. When pressure flexes the Bourdon tube, the pointer is always positively positioned. You can rely on the Duragauge for precise accuracy in measuring pressure no matter how severe the conditions of service.

Correct calibration is guaranteed: the one-piece link between movement and Bourdon tube prevents slippage or parting under tension. Recalibration is easy from front or rear. Universal adjustability permits uniformly graduated dials.

You can order Ashcroft Duragauges with all-stainless-steel movement or stainless steel with nylon bearings and pinion gear. A complete choice of Bourdon tube materials, pressure ranges, dial sizes and case designs and materials is available. Your industrial supply distributor will gladly help you select the best combination for your requirements. So, be certain of highest sustained accuracy, durability and economy – specify Ashcroft Duragauges.

Ashcroft Duragauge in Alumalife® case—a lifetime case made of special aluminum alloy.

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ASHCROFT PRESSURE GAUGES

A product of

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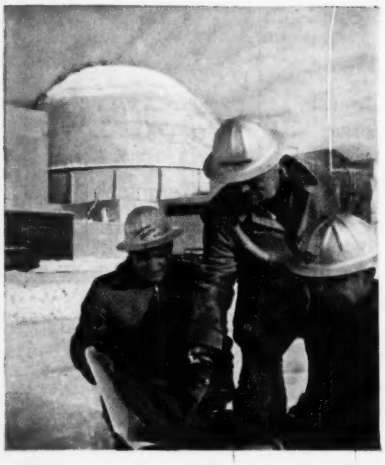
For more facts circle 202 on Reader Service card, p 125

INNOVATIONS IN FLUID HANDLING: #1 OF A SERIES
STEAM GENERATING GROUP
ELECTRIC GENERATING GROUP
As the manufacturer of all major components of the fluid handling group (pumps, condensers, deaerators, ejectors) Worthington has a reservoir of experience and knowledge that can benefit you.

NUCLEAR CONDENSER

Dresden unit is tailored to special needs of nuclear plants



Engineers of General Electric, Worthington and Bechtel Corporations worked together closely with Commonwealth Edison on new Dresden Station.

Four major problems faced Worthington in the design of a 120,000 sq. ft. condenser for the Dresden Nuclear Power Station being built by General Electric Co. for Commonwealth Edison Co. and the Nuclear Power Group, Inc. They were: (1) necessity of handling full output of dump steam, (2) quantities of free gases in the steam, (3) maintaining condensate purity, and (4) providing radioactive decay time for the condensate.

Worthington engineers, working in close cooperation with the customer, his design engineers and contractors, solved these problems. To handle dump steam, pressure breakdown devices were installed in the condenser itself and in a special "blister" on one side of the condenser. An extra large ejector was used to handle quantities of free gases. And to maintain condensate purity double tube sheets were used and special deaeration features were provided.

Radioactive decay time was provided by means of the special hotwell which is baffled to make the transit time of the condensate long enough to allow short-lived radioactive impurities to decay to lower levels.

This typical example shows you how Worthington applies its experience as a manufacturer of all major components of the fluid handling group in solving the problems of one particular element. To put this progressive "know how" to work on your power plant problems, conventional or nuclear, contact your nearest Worthington district office. Or write to Worthington Corporation, Section 45-8, Harrison, N. J. In Canada: Worthington (Canada) Ltd., Brantford, Ontario.

WORTHINGTON

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